Excelsior
MINING CORP

VIA: Email & FedEx Tracking # 7715 4298 5083

February 22, 2018

David Albright
Manager, Drinking Water Protection Section
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, California 94105

Dear David:

Excelsior Mining Corporation (Excelsior) has reviewed comments received by Earthworks and Tom Myers (collectively the "Myers" comments) during the public comment period for the Gunnison Copper Project UIC draft permit and wanted to provide you our responses to some of those comments. As you are aware, Excelsior has expended a great deal of time, effort, and money to develop a mining plan that will meet the rigorous requirements of the UIC regulations. We believe this plan is sound and will be protective of the public and the environment at and around the mine. Many of Myers comments are frivolous and repetitive and clearly demonstrate a lack of understanding of the proposed project by the reviewers. Excelsior is concerned that the reviewers of the UIC permit are only interested in delaying or ending the project. We have tried in good faith to negotiate with Amerind and Earthworks, the two most vocal opponents of the project, to no avail. It is clear to us that they are using delay tactics to avoid final issuance of the permit.

The significant assertion from the forty plus pages of comments, is that solutions will migrate out of the wellfield, and be undetected by the proposed monitoring network. This demonstrates a total lack of understanding of the permit and proposed monitoring. The Intermediate Monitoring Wells (IMWs) were selected because they intersect every significant structure within the proposed wellfield (see Table A-2 in Attachment A-1 of the permit application). Therefore, any migration of solution along any of the major potential fluid channel ways will be detected before it can leave the wellfield, and in fact before it even reaches the HC well boundary. Minor structures are connected to the major structures and dispersion will ensure the detection of any migration. In addition, HC wells are specifically placed to detect, intersect and/or capture solutions from not just these major structures, but anything within the hydraulic influence of the HC well. Therefore it is not feasible or realistic to assert that "solutions will leak undetected and uncontrolled" from the wellfield.

Earthworks and Amerind provided comments on the APP in 2017. Similar and/or identical comments have been provided by Amerind/Earthworks on the UIC permit. These comments focus on the model and not on the permit, and totally disregard the significant technical expertise involved from both agencies in the development of the comprehensive monitoring network.

While the comments raise concerns about groundwater flow directions and the impacts of the mining operations, Dr. Meyers, in an internal memorandum dated September 25, 2017, obtained from EPA through a FOIA request, indicated his belief that an appeal of the APP permit would not be granted. His reasoning is provided in this quote from his memorandum (page 2, first full paragraph):

> *"The larger question is this: what do we get from an appeal hearing? We are not going to show that the mine is a threat to Dragoon-area groundwater, simply because the flow gradients are to the east, not towards the community or its well. We do not have evidence to show their potentiometric surface maps (flow direction) are so wrong that the flow is actually toward Dragoon. That means I do not think we could get the project denied. The best we would get is a few more POC wells. I do not recommend an appeal because it is a huge effort for very little real potential gain."*

We could not agree more – the mine will not be a threat to Dragoon-area groundwater. In fact, the mine will not be a threat to any USDWs.

Excelsior has, in the attached document, provided our responses to key issues in the Meyers comment memorandum on the UIC. Clearly most of these comments were provided verbatim to ADEQ at the time the Draft APP permit was under public comment. We did a Word document compare to point out what has been changed between the APP and UIC comment letters by Meyers. ADEQ reviewed Meyers comments and provided their own responses which we have included in our responses.

The Meyers comments on the UIC do not raise any new or significant issues regarding the Gunnison Copper Project Draft UIC. Please call me if you have any questions concerning our responses to the UIC comments.

Sincerely,

Stephen Twyerould

President & CEO

Attachment

Excelsior Mining, February 6, 2018

In the document that follows, a Technical Memorandum dated January 6, 2018 (incorrectly dated 2017) to EPA by Dr. Tom Myers with his comments on the Gunnison project UIC application has been compared to a nearly identical Technical Memorandum submitted to the ADEQ dated July 27, 2017 and prepared by Dr. Meyers with his comments on the APP application. Red line changes are what were added or deleted when Dr. Meyers modified the July 27, 2017 ADEQ memorandum with his comments on the UIC application.

In addition, Excelsior has provided responses to a number of Meyers' comments. ADEQ had also provided responses to a number of Meyers' comments and, because the memorandums are quite similar, the ADEQ responses have also been included and are shown in italics. Both Excelsior and ADEQ comments are contained within brown shaded text boxes. The portion of Meyers' memorandum addressed by a particular text box is highlighted above the box in green.

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Technical Memorandum
Review of Underground Injection Control~~Aquifer Project~~ Permit and Application
Gunnison Copper Project

January 6~~July 27~~, 2017

Dragoon, Arizona

Summary and Conclusions

Excelsior Mining Arizona proposes to construct an in-situ leach and recovery copper mine near Dragoon, Arizona. This technical memorandum reviews the draft Underground Injection Control Permit (UIC) and application materials~~Aquifer Protection Permit Application~~ for the Gunnison Copper Project.

The regional aquifer under consideration extends from the Little Dragoon Mountains in the west to the Gunnison Hills in the east and Dragoon Mountains on the south. Groundwater generally flows from recharge areas near the Little Dragoon Mountains and within ephemeral channels in the west almost directly eastward across the site to gaps in the mountains north and south of the Gunnison Hills. Groundwater would flow through these gaps eastward to the broader Willcox Valley.

The aquifer properties are highly heterogeneous and oriented according to the dip of faults and fracturing that occurs naturally in the area. However, the analysis presented in the UIC~~APP~~ application averages the hydrologic properties so that heterogeneity is not well considered and the importance of preferential flow paths is minimized. Fracture intensity and porosity modeling shows substantial variability that the application tends to present as averages. Even though the pump tests indicate that properties vary by direction, with a tendency for the northwest to southeast direction to have higher conductivity, the analysis in the application does not account for this. Averaging and failure to consider directional differences causes the application to not adequately consider preferential flow paths caused by fracturing and through which much more groundwater, and injected fluid, would flow.

[redacted]

- The groundwater divide is not an element of Best Available Discharge Control Technology (BADCT), nor will it be relied upon to contain solutions. The groundwater divide was simply identified as part of the overall hydrogeologic characterization of the site, as required in the permitting process. The operation of the wellfield, including hydraulic control pumping, maintenance of inward gradients, overall net extraction, and monitoring at observation wells and intermediate monitor wells is the mechanism by which southward migration is prevented.
- The groundwater divide was also not integrated into the model as any sort of boundary. It is assumed that the divide (under steady-state conditions) falls somewhere in the area of the project, based on available water level data. Once the hydraulic control pumping is initiated, it no longer matters where it falls as the control system would override the steady-state flow regime.

[redacted]

[redacted]

- See comment above. The groundwater divide is not an element of BADCT for the wellfield nor is it required for or used in the control of solutions and is therefore not relevant.

The project is an in-situ leach and recovery project for copper (Cu) in the bedrock formations underlying the basin fill at the site. The project involves injecting an acid solution into the groundwater of the bedrock aquifers so that it can leach Cu which would then be recovered in capture or collection wells. The well layout would have four collection wells surrounding each injection well, but a map of the pattern suggests that each collection well would be part of the four collection wells surrounding other injection wells. The injection rate would vary with time throughout the project life, with the total injection increasing~~ranging~~ from 5300 to 25,600 gallons per minute with over the project life.~~lower rate for the first ten years.~~ The injection/collection process would collect more water than is injected, which should cause a general groundwater level drawdown within the well field. A line of hydraulic control~~collection~~ wells would surround the well field and be designed to withdraw water and create a trough in the potentiometric surface intended to prevent fluid from escaping from the wellfield. Predicted drawdown from hydraulic control wells would extend to the east of the well field by 1200 to 1500 feet from the control wells at maximum pumping based on modeling. [redacted]

- Aquifer testing has demonstrated a high degree of connectivity within bedrock due to faulting, fracturing, and bedding plane pathways. While hydraulic control wells will be placed to intersect major pathways, it is not necessary to intersect each flow path to contain solutions. The drop in pressure (i.e. the lowered potentiometric surface) is sufficient to contain solutions in all fractures whether directly or indirectly connected to a hydraulic control well.

The processing of copper would allow most other metals to remain in solution, and be circulated back through the system, so that the water would have concentrations of metals and some anions that are multiple times their water quality standards. Concentrations of cadmium, lead, selenium, nickel, thallium, zinc, and fluoride, among others, would be orders of magnitude higher than background levels and most water quality standards. The incredibly poor water quality of the leach solution exemplifies why preventing any of it escaping the system is critical.

The application argues this site is favorable for "maintaining control of the leach solution" because there is limestone within and downgradient of the wellfield, which would provide a large attenuation and neutralizing capacity. [redacted]

- Excelsior does not intend to use the neutralizing capacity of limestone to prevent excursions during operations; however, acid neutralization is an element of the wellfield closure strategy. Containment during operations will be accomplished through pumping either mine block recovery wells or hydraulic control wells.

Groundwater model simulation of the ISL project is too coarse, meaning it was completed without sufficient detail, and too unrealistic, to provide much confidence in the results. Only the hydraulic control wells were simulated. The ISL system was simulated by simply placing contaminant particles in the model at the edge of the interior wells fields, but not under pressure as they will be during operations. High injection rates and heterogeneities in the well field could easily cause flow paths not captured by collection wells. Without simulating the injection/collection wells, this model does not provide reliable information regarding the effect of the injection/recovery system on local or regional flow paths.

The model is too coarse because the pathways are, at a minimum, 50-feet wide (model cell sizes) which means the hydrologic properties are averaged over an area that wide. It completely misses the potential narrow pathways that could preferentially allow particles to exit the system. Simulation of mining should be improved by simulating the actual injection/recovery wells, with injection rates depending on the localized conductivity and pressures that would be acceptable for operations. The model should be discretized into much smaller cells at the mine so that injection/recovery can be simulated more accurately. The geology/fracture intensity model should be used at a smaller scale to provide more detail of flow paths through the well field.

- The groundwater model was developed specifically to assess hydraulic containment at the wellfield boundary. Because Excelsior intends to operate the wellfield where injection is approximately equal to recovery pumping, there is no overall hydraulic head placed on a mining block/area. As a result, there is no overall excess of hydraulic energy in the mining area to drive significant excursions from the mining block. Therefore, the hydraulic containment system is well represented by the model.
- Excelsior and ADEQ recognized that a strong monitoring program is needed to assure that wellfield operations do not result in the loss of mining solutions to surrounding areas. To that end, Excelsior added numerous monitoring wells – designated Intermediate Monitoring Wells or IMWs – that surround mining operations at all times. The IMW network is intended to provide early warning of potential solutions migrating from the mining block. This will allow operators to adjust wellfield pumping to return the solutions to the mining block or adjust the number, placement or pumping of hydraulic containment wells to ensure capture. It is in Excelsior's best interests to manage mining solutions in this way as these solutions contain the product that Excelsior will market and sell.
- As mining progresses, Excelsior will continue to obtain detailed hydrological and subsurface information regarding the fractured rock system and will use this new information to further improve and refine the groundwater model. The performance of the groundwater model and containment systems requires reporting to the EPA and ADEQ on a regular basis and if needed, changes will be made to containment, operations and/or IMW monitoring.
- Because the groundwater model used data from the detailed geologic model for the project to define the model cells, this detailed geologic/fracture intensity model was based upon a 100 foot by 50 foot cell size. It was completely logical to use a 75 by 75 foot model grid to accommodate these data in the project groundwater model.
- Irrespective of the cell size and hydrological model, detailed geological data over the entire deposit allows for the accurate mapping of major and minor fault zones and structures. Monitoring has been specifically designed to intercept these structures. Due to the density of geological data (Figure A), the realistic probability of an unknown significant structure is non-existent. All known structures will be monitored.

<u>The monitoring plan proposed for the project area is insufficient to protect downgradient water resources. Although there are several rings of monitoring wells, they would be insufficient. The spacing does not account for aquifer heterogeneity, in both the horizontal and vertical</u>

direction. In a highly fractured aquifer, contaminants would follow the most transmissive pathway, but there is no certainty these pathways would be monitored. This is especially problematic with respect to the potential for flow southward through fractures perpendicular to the regional gradient. The monitoring would not detect excursions through the southern project boundary.

- The ore body at the Gunnison project lends itself to insitu mining methods because it is intensely and pervasively fractured. If it was not, insitu mining would not work. For this reason, the proposed monitoring program, including numerous wells surrounding mining operations, will provide a sufficient level of detail to detect any excursion of mining solutions from a mining block.
- In response to APP commenter, Thomas Sheridan, ADEQ stated "*The Department has thoroughly considered the ways in which fluids can escape from the injection activity and has concluded that the Aquifer Protection Permit (APP) meets all statutory and regulatory requirements and includes robust monitoring which allows us to understand the current status of the aquifer and alert the agency to any degradation caused by the project. The APP requires the permittee to conduct ambient groundwater monitoring of point of compliance (POC) wells located at the edge of the pollutant management area (PMA), Intermediate Monitoring Wells (IMW) located within the PMA, and Observation Wells (OW) located in the vicinity of Hydraulic Control Wells (HCW) located at the edge of the in-situ wellfield. Excelsior is also required to monitor within the PMA (in the IMWs) to monitor the performance of the in-situ leaching and recovery system, and monitoring of POC wells to ensure compliance with the permit.*

There are far too few point of compliance (POC) wells and the design could allow contaminant plumes to escape the well field undetected. The POC wells also have screens, or open intervals, that are far too wide that will allow the contaminants to be diluted by clean flow either above or below the pathway transporting the contaminants. POC wells should be redesigned according to results from modeling dispersion with the more-detailed model. The POC wells should have multiple screens so that individual productive flow zones can be sampled without dilution from above or below.

- Excelsior's monitoring program has been designed to detect releases of mining solutions long before anything is detected in a POC well.
- As specified in Arizona Statute (ARS 49-244), the point of compliance is defined as: "a vertical plane downgradient of the facility that **extends through** the uppermost aquifers underlying that facility." [emphasis added] In this case, the uppermost aquifer is the portion of the bedrock where injection and recover operations will occur. Therefore, the POC well must be screened through the entire sequence of rock including all fractures as required by Arizona Statute.
- In the unlikely event that a downgradient land owner would construct a well in this bedrock aquifer, the well would have to be constructed with sufficient screen length to produce a usable amount of water. In this bedrock setting, this would require a considerable screen length encompassing all fractures. For this reason, monitoring the entire mining zone is appropriate as it reflects the potential useable portion of the aquifer.
- In response to commenter to the APP, Pete Dronkers, ADEQ (Response to Comment #5.1) stated: *ADEQ does not agree that the request for additional POC wells at this time is warranted. Based upon the information that has been collected to date, the estimated travel times to the currently proposed POC well locations is several years, any further distant POC wells would have much larger travel times and would not indicate a problem at the mine.*

The following sections provide much more detail regarding the application, and the factors of it that should be improved to make the UIC~~APP~~ application more protective of the environment. This is especially true for the groundwater modeling and the POC wells.

Introduction

This technical memorandum is a review of the draft Underground Injection Control (UIC) Permit and supporting documents~~Aquifer Protection Permit Application~~ for the Gunnison Copper Project proposed by Excelsior Mining Arizona. ~~(CCA 2016). Clear Creek Associates attached several other studies to the application that were also reviewed herein. These included the Aquifer Testing Report (Appendix G) and the Groundwater Modeling Report (Appendix I). Other appendices contained data and other information that supported the application or Appendix I, including a Hydrology Investigation Well As-Built Diagrams (App C), Hydrogeological Well Completion Report (App F), Geophysical Logs (App H), and Fracture Gradient Testing and Analysis (App N).~~ References herein~~within this review~~ are to the draft permit or its appendices, as well as to CCA (2016), the application for the Arizona Aquifer Protection Permit (APP), because it provides a good discussion of how some aspects of the project tie together. Many of) ~~or to~~ the documents are the same for each permit, but have different names~~various~~

~~appendices~~.

Regional Hydrogeology

Surface formations at the site and around the valley from the Little Dragoon Mountains to the Gunnison Hills are basin fill except near the mountains where there are bedrock outcrops. Basin fill is generally eroded material from nearby mountains that has settled into a valley and has been minimally sorted by rivers and streams. The basin fill near the proposed wellfield is saturated only in one area near the project site. East of the project site and near Dragoon, the basin fill approaches 1000 feet in thickness in a deep north-south trending trough.

Groundwater generally flows from recharge areas near the Little Dragoon Mountains and within ephemeral channels on the west side of the valley through bedrock to deep basin fill almost directly eastward across the site. Groundwater recharge is precipitation that percolates through the soil and rock to reach the groundwater table. Depth to water ranges from 244 to 655 feet, with most water levels below the top of bedrock except for a north-south swath across the western third of the site where the water levels indicate the aquifer is confined (CCA 2016, p 5-9). Confined aquifers are those in which the water pressure causes water level in the wells to rise above the top of the aquifer, the confining layer that separates the aquifer from overlying formations.

Groundwater flowing in bedrock fractures to the east would reach the basin fill in the deep trough east of the site. Groundwater likely discharges to saturated fill in the deep trough. Residence time, or the average time for water to cycle through the aquifer, in the fill is likely very long, on the order of at least centuries if there is mixing. If mixing is limited, the residence time for some of the water could be much shorter. East of the proposed wellfield, groundwater either flows south to a gap between the Gunnison Hills and Dragoon Mountains or north of the Gunnison Hills.

The regional potentiometric surface slopes steeply east until reaching the saturated basin fill east of the project site where the slope flattens greatly (Figure 1). Flow in the bedrock is mostly east toward the saturated basin fill. In the fill, the slope is much flatter but to the south and the discharge point east to the Willcox Playa area. Hydraulic gradient, slope measured in feet per foot, is significantly flatter through the area of the deposit, and proposed wellfield, about 0.01 or lower than in bedrock to the west (CCA 2016, p 5-11). The application claims it is due to - ~~more fracturing and higher permeability associated with skarn mineralization but the gradient flattening could also be due to flatter topography and structures downgradient, such as impervious faults on the west face~~
more fracturing and higher permeability associated with skarn mineralization but the gradient flattening could also be due to flatter topography and geologic structure downgradient, such as impervious faults on the west face of the Gunnison Hills damming or diverting the flow.

Figure 2, showing more detailed localized groundwater contours, does not replicate the regional divide. Figure 2 contours demonstrate the complexity of groundwater flow through the site.

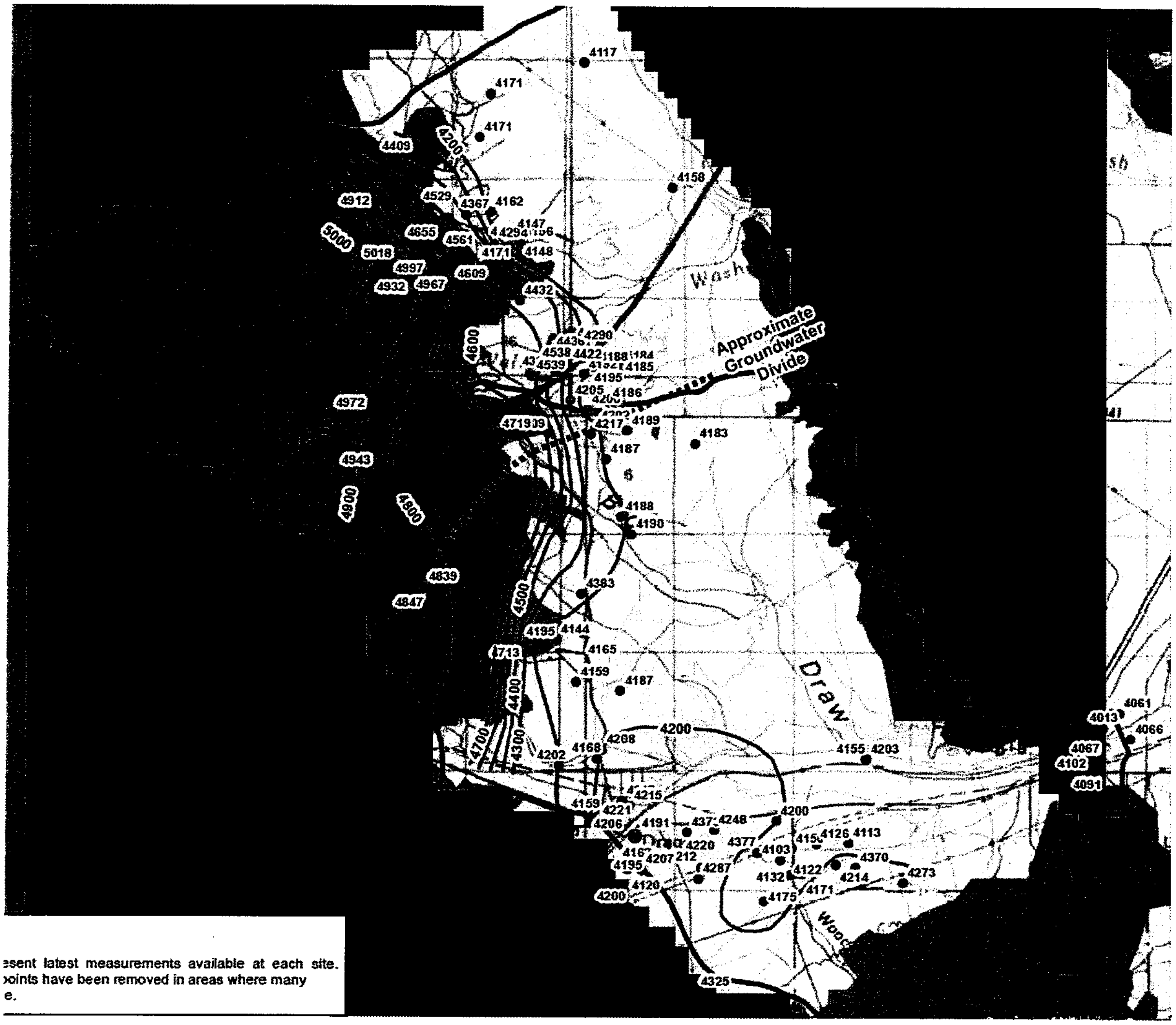


Figure 1: Figure 11 from <u>Attachment A-2</u>~~Appendix I~~ showing the regional potentiometric surface. The red boundary line is the bounds of the regional groundwater model.

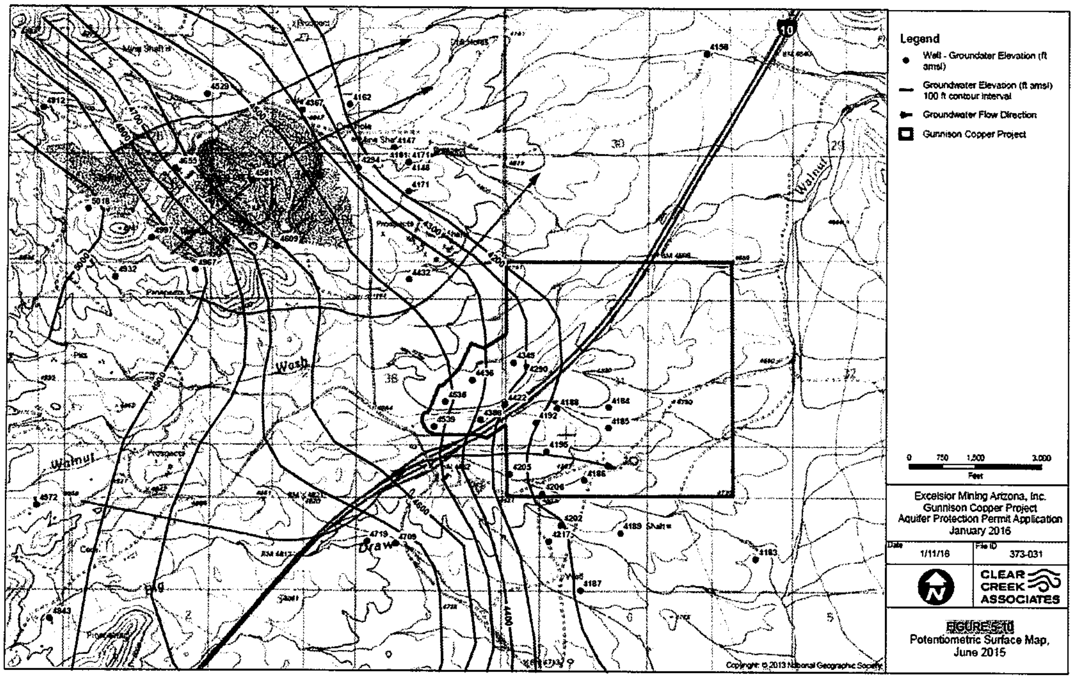


Figure 2: Figure 5-10 from Clear Creek Associates (2016) showing the potentiometric surface at the site and to the west and northwest.

- See comment above. The groundwater divide is not an element of BADCT for the wellfield nor is it required for or used in the control of solutions and is therefore not relevant.

CCA (2016) does not present a natural water balance for the aquifer. A water balance would be an estimate of recharge and discharge from the aquifer. The Application describes recharge properly in that it occurs from precipitation at higher elevations or from runoff through washes at low elevations, estimating that about 3% of the average 12.5 in/y precipitation becomes recharge across the basin.

- The hydrogeology discussion should present a water balance for the regional aquifer system with an estimate of recharge and an estimate of groundwater flow leaving the basin through the two gaps on the east.

- A water balance for the model domain selected for the Gunnison Project is rather simple. It includes only recharge from precipitation falling on the model domain area and outflow of groundwater through the two gaps in the Gunnison Hills. Other input/output parameters found in other basins are simply absent here including perennial water bodies such as rivers or lakes; springs and seeps; diversions of surface water; large pumping wells for municipal, industrial, or agricultural purposes; and irrigation of agricultural lands. Because of its simplicity, a detailed water balance is not necessary.

- The key water balance input assumption to the groundwater model is the amount of infiltration to the model domain due to natural precipitation. Clear Creek spent considerable time assessing this input parameter because it can be linked to local rainfall for which there are good historical records. In addition, other researchers from agencies such as the USGS have established what the likely percentage of precipitation becomes groundwater recharge for the climatic conditions in this area. Recharge from precipitation is the only source of water to the model domain chosen for this project because all upgradient boundaries are at the edges of the hydrologic basins making up the model domain. If the amount of water entering the model via precipitation can be justified, the amount of water exiting the basin via groundwater is easily estimated if the system is in steady state, which this is. Steady water levels have been measured in numerous wells throughout the basin; therefore, the model was calibrated in steady state mode. The amount of recharge to the model domain is discussed in detail in the UIC application (Section 2.5.2, Table 5, Appendix A-2). The estimated recharge was 738.2 AF/yr entering the model domain via recharge from precipitation (Table 5), therefore the amount of groundwater flow that leaves the model through the Walnut Wash and Big Draw gaps should be the same. The steady state model simulates 737.6 AF/yr leaving the model domain through the gaps in the Gunnison Hills. There are no other inputs or outputs to/from the model domain in the steady state, pre-mining model.

- ADEQ had the following response to this comment in the APP Responsiveness Summary (ADEQ response #6.1):

ADEQ agrees that the groundwater model report did not provide a water balance. The permit has been modified to include groundwater flow model evaluations on a periodic basis as detailed in ADEQ Response to Comment #5.1. The report(s) will include a water balance.

Although the groundwater model report did not include a water balance, the calibration analysis conducted by Excelsior demonstrates that the model is calibrated. In addition, the sensitivity analysis conducted by Excelsior provided information on which of the *hydrogeologic parameters the groundwater model is sensitive to. ADEQ believes the predictive capabilities of the model are adequate to evaluate the effectiveness of the proposed BADCT. Once long term injection/recovery and hydraulic control begins, the additional data will be used to re-evaluate and calibrate the model.*

Geologic formations beneath the basin fill are in order of increasing depth are Me (Escabrosa Limestone), Dm (Martin Formation), Cau (Upper Abrigo), Cam (Middle Abrigo), Cal (Lower Abrigo), and Cb (Bolsa Quartzite) with pCu (PreCambrian Undivided) underlying these formations. These formations dip about 20 to 40 degrees to the east, and there are several near-vertical faults that offset the formations. Mineralization occurs in most of these with the base of the well field expected to be in the Cal formation (CCA 2016, Figures 3-5, -6, and -7). The bedrock surface is highly variable, which makes the basin fill thickness vary substantially. Bedrock elevation contours show significant variability over short distances, including drops of as much as 300 feet (CCA 2016, Figure 5-13).

Local Hydrogeology

There are 202 known wells within ½ mile of the project, although these are mostly mine exploration drill holes including those of Excelsior (CCA~~Clear Creek Associates~~ 2016, p 5-1). Most are owned by mining companies. Excelsior constructed 32 total wells through basin fill into the bedrock (Figure 3~~2~~). The deepest wells, greater than 1400 feet, are in the south-central and southwest portions of the project area (Figure 3). There were additional coreholes drilled, to as deep as 2500 feet

~~southwest portions of the project area (Figure 2). There were additional coreholes drilled, to as deep as 2500 feet~~ (CCA 2016, p 5-4).

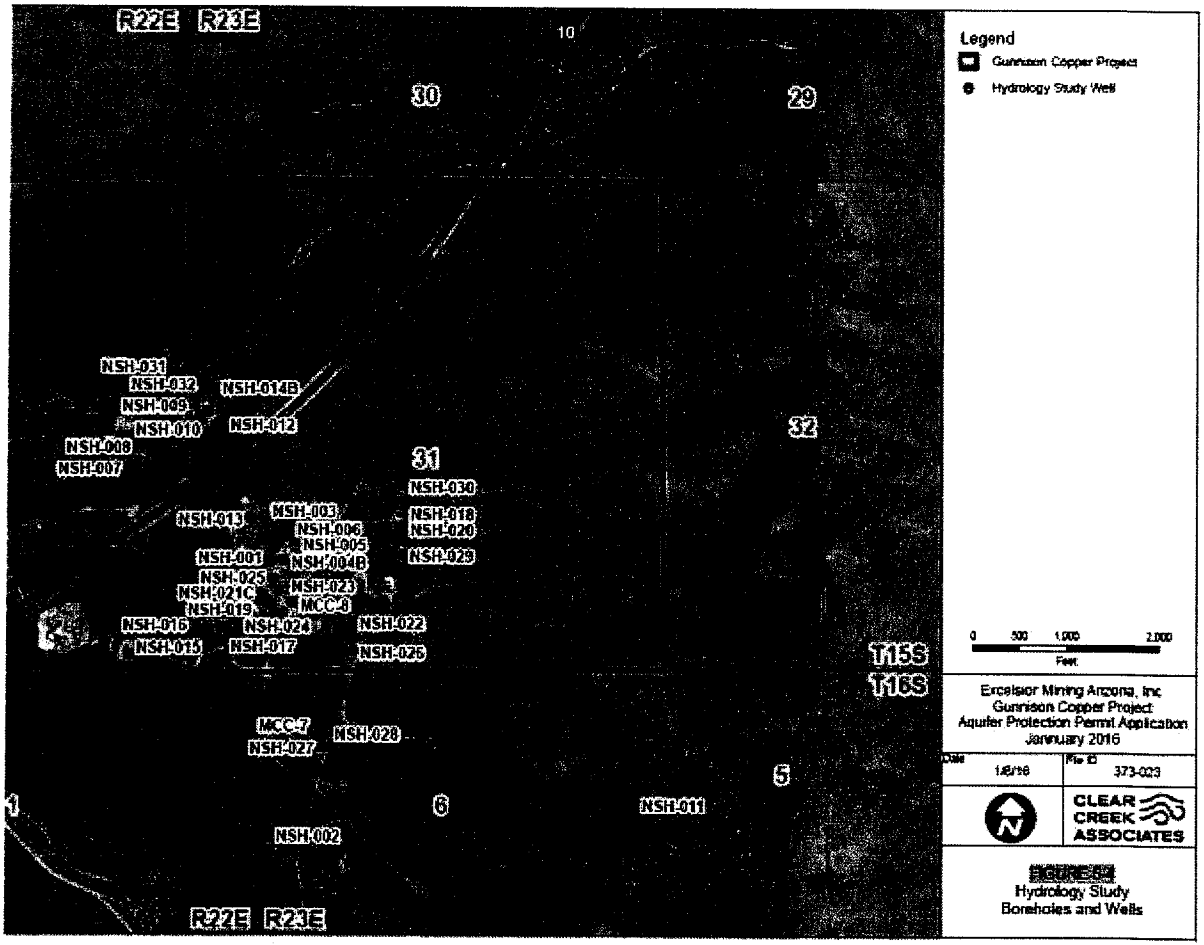


***Figure* <u>3</u>~~2~~:** [redacted]

- Please note that the boreholes and wells shown in Figure 5-4 above are only wells installed for hydrogeological studies. Numerous other coreholes were used in the development of the geologic model. The geologic model defined the distribution of fracture intensity which was in turn used to define the distribution of hydraulic conductivity because fracture intensity can be related to hydraulic conductivity (described elsewhere). Figure A shows the number and location of coreholes used for geologic mapping and therefore reflects the density of data used for the hydrogeologic model.

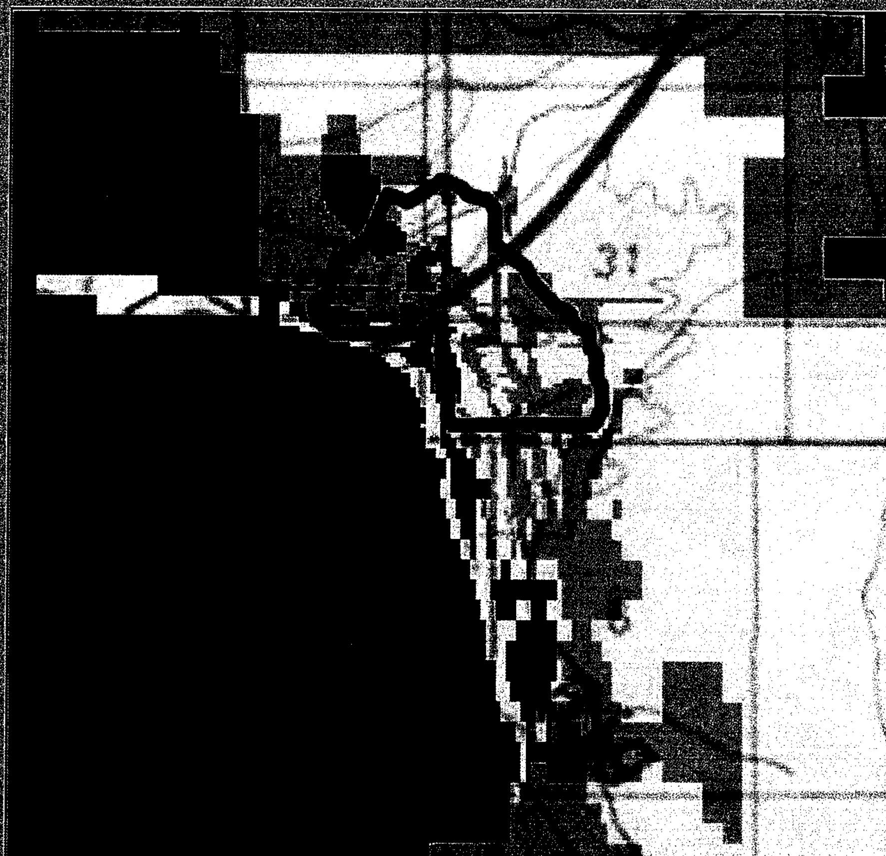
Aquifer Properties and Pump Tests

Excelsior (<u>Attachment A-3</u>~~Appendix G~~) estimated most material properties using pump tests and geophysical techniques to estimate fracturing the various wells. Pump tests were completed with four two- hour steps followed by five days of steady state pumping and with three days of recovery monitoring. Drawdown in observation wells was monitored so there is an indication that properties in one direction is different from properties considered in a different direction, which may be the effect of fractures.

Attachment A-3~~Appendix G~~ Table 1 summarizes estimate transmissivity (T), maximum pumping rate (Qmax), and drawdown (Hmax) for each pump test. Transmissivity is the product of conductivity (K) and aquifer thickness. Conductivity K is the ease with which groundwater flows through a formation. The pump tests show a very large variability in T, more than three orders of magnitude, with values from 2 to 4000 ft^2/d (K varies from 0.01 to 9.8 ft/d based on ~~formation. The pump tests show a very large variability in T, more than three orders of magnitude, with values from 2 to 4000 ft²/d (K varies from 0.01 to 9.8 ft/d based on~~ thickness equal to pumping screen thickness, Attachment A-3~~Appendix G~~, Table 3) and maximum pumping rates from 2 to 170 gpm. Lower pumping rates generally coincided with a low T. The author indicates that the variability "is to be expected as some wells were completed in highly fractured rocks while others were in unfractured or solid rock" (Attachment A-3~~Appendix G~~, p 6). Because the formations dip, it is likely that most wells intersected ~~some~~ fracture zones so that T probably is related to the fracture density rather than simply the presence of fractures. The large range in K around the site indicates the site is highly heterogeneous. [redacted]

[redacted]

- Horizontal anisotropy is indeed accounted for in the model through the distribution of high permeability zones representing intensely fractured faults. The K distribution zones are based on the detailed geologic model which is itself based on numerous core holes. Figure A shows the locations of the core holes used to develop the geologic model. Faults and fracture zones are well defined using this network of core holes.
- Extract from Figure 29 showing K distribution for Layer 5 of the model. Horizontal anisotropy is readily apparent.



- ADEQ found that there was no need to simulate horizontal anisotropy. They state (ADEQ APP Response #6.2): *The groundwater flow model does consider horizontal anisotropy in its design. The major faults systems are presented with higher hydraulic conductivity values essentially creating anisotropy within the model. This method also accounts for any preferential flow paths (major fault systems) that may be present.*

The pump test for well NSH-005, which is completed in bedrock, caused a larger drawdown in basin fill well NSH-006 than did the pump test directly in well NSH-006 (1.8 ft v 0.4 ft). Both wells are completed near the Forty Mile Fault structure (Attachment A-3~~Appendix G~~, p 15). Well NSH-006 has about 30 feet of saturated fill so it is in the primary unconfined aquifer at the site. This substantial response indicates the fault connects the bedrock with the basin fill so that stresses in the bedrock that affect the fault will also affect the water in the basin fill. This observed connection suggests that injected water (lixiviant) near this location could be forced upward into the unconfined aquifer. Pump testing at NSH-006 caused only 0.4 feet of drawdown but the pumping rate was very low; small drawdowns were observed at two bedrock wells (Figure 3~~37~~) confirming the connection. It would have been useful to pump this well at a higher rate to better test the connections to the bedrock aquifers.

- Alluvium below an elevation of 4185 feet within the AOR has been included in the Aquifer Exemption to address the possibility of a connection between bedrock faults and the limited area of saturated basin fill.

Attachment A-3~~Appendix G~~ presents a directional plot of conductivity with azimuth~~, which they claim shows they can average the K values without considering direction~~ (Figure 43). Rather than showing "that the hydraulic conductivities are relatively evenly distributed with little prevalent direction" (Attachment A-3~~Appendix G~~, p 31), Figure 4~~3~~ shows a substantial correlation with direction. This is especially true for a direction from midway between north and northeast and between south and southwest, where the K exceed 4.0 ft/d, and for a roughly perpendicular direction along

which K is just over 3.0 ft/d. Additionally, between those transverse K trends, there is another line of about 3.2 ft/d trending from between north and northwest to between south and southeast. K in other directions is less than half as much. The trends show a perpendicular fracture pattern, but does~~es~~ not demonstrate that "the fracture patterns intersect sufficiently at the well spacing of 100 feet to smooth out, for the purpose of hydraulics, discrete fracture spacing which is on the order of one foot" (Attachment A-3~~Appendix G~~, p 31). There is nothing in the Appendix, or anywhere in the Application, that indicates the spacing of the intersection of fracture patterns

~~patterns~~ or of one foot discrete fracture spacing.

Figure 123. Compilation of K-values from the Gunnison ore body by azimuth and magnitude

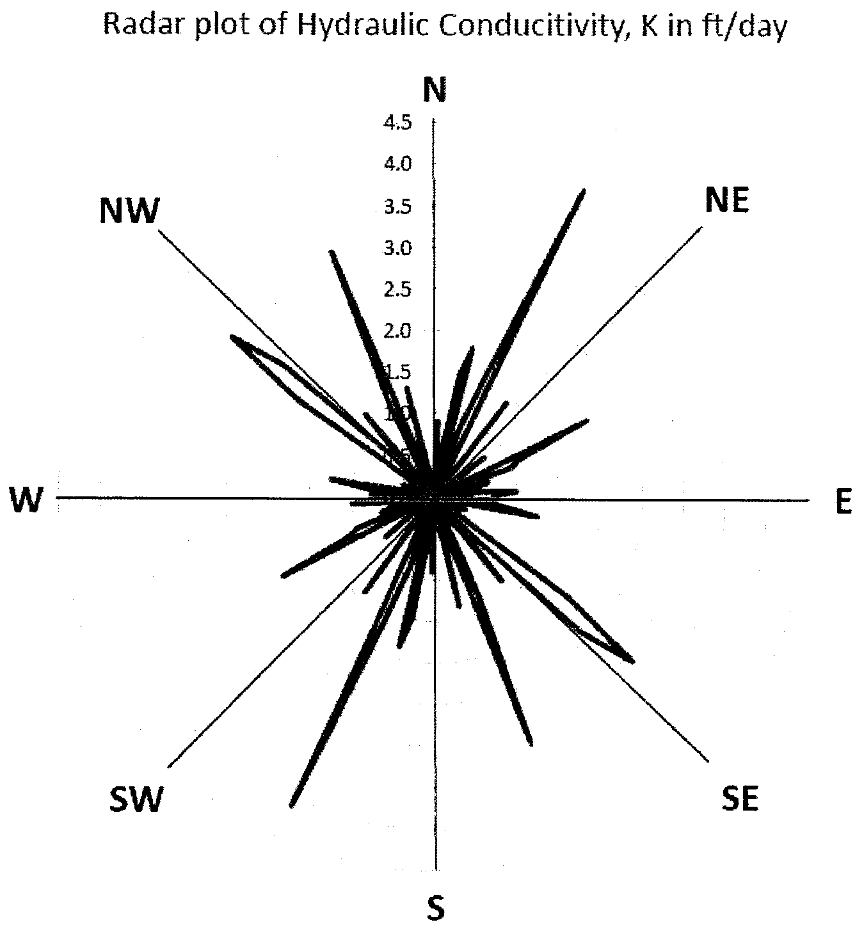


Figure ~~3~~4: Figure 123 from CCA (2016) Attachment A-3~~Appendix G~~ showing the relation of hydraulic conductivity with azimuth between pumping and observation wells.

The property data identified in Attachment A-3~~Appendix G~~ was used "to populate and calibrate the hydrogeological flow model" (Attachment A-3~~Appendix G~~, p 32), but they ignore heterogeneity and directional tendencies.

- The comment is incorrect. Heterogeneity is built into the model via the relationship of hydraulic conductivity zones to the geologic model. See ADEQ APP Response #6.2, below and the last response, above. Higher conductivity pathways are included in the groundwater model as higher K zones.

The application claims that even "the low-yield wells demonstrated long-distance hydraulic connectivity with observation wells" (Attachment A-3~~CCA 2016~~, p 37~~5-12~~), based on responses even when the wells were not screened in the same fracture zone. In a confined aquifer, a stress in one location will propagate as a pressure response in all directions; Excelsior properly references this response as indicating the aquifer is confined. However, Excelsior may be implying that this means that groundwater (and contaminants, or lixiviant) will flow from one point to the other. As noted in the pump test analysis, due to the directional tendency of the fractures, much of the flow may be parallel. Pressure responses occur in all directions in a confined aquifer, and may not represent proof of flow between the two points. This interpretation is important because of the need for the injection/collection system to capture flow from all points of the system.

Attachment A-2~~However, Appendix I~~ notes that in bedrock the model treated K as equal in all directions except for the basin fill. By not considering anisotropy the Application (most importantly, in the modeling) ignores preferential flow either on the horizontal plane or vertically. Fractures trend from northwest to southeast which suggests the K along that direction should be considered higher than in other directions. The formations dip to the east which also suggests that K is higher parallel to the dip than in other directions. The Application ignores these issues even though geologic figures presented within the application provides the relevant evidence regarding the dip. For example, drawdown from pump tests in an observation well more than 1000 feet from pumping wells indicates "good connectivity" [illegible] in a prevailing direction between the pumping and observation wells.

- Excelsior should consider horizontal anisotropy in its modeling and project design. The effects of not considering this are better considered below in the discussion of modeling.

- ADEQ responded to this comment as part of the APP Responsiveness summary (ADEQ Comment #6.2) as follows:

  The groundwater flow model does consider horizontal anisotropy in its design. The major faults systems are presented with higher hydraulic conductivity values essentially creating anisotropy within the model. This method also accounts for any preferential flow paths (major fault systems) that may be present. In addition, Excelsior provided in the April 2017 "Gunnison Copper Project, Cochise County, Arizona, Aquifer Protection Permit Application Inventory No. 511633 Response to Comments" several figures that show the horizontal area of influence for aquifer testing conducted at the site. These figures indicate the primary preferential flow paths are the major fault systems. These figures include Figure 2-1 "Aquifer Testing Area of Influence, NSH-013", Figure 2-2 "Aquifer Testing Area of Influence, NSH-021C", Figure 2-3 "Aquifer Testing Area of Influence, NSH-024", and Figure 2-4 "Aquifer Testing Total Area of Influence: NSH-013,NSH-021C, NSH-024".

  Additional figures provided the locations of IMWs to be used to monitor Mine Block 1 along with an overlay of the aquifer testing total area of influence shown in Figure 2-5 (Figure 2-5 "Intermediate Monitoring Well Locations: Year 1"), locations of Mine Blocks 1 through 5 with the same aquifer test overlay shown in Figure 2-6 (Figure 2-6 "Intermediate Monitoring Well Locations: Year 5). This same evaluation and figures were presented for Year 10 and Year 13 (Figure 2-7 "Intermediate Monitoring Well Locations: Year 10" and Figure 2-8 "Intermediate Monitoring Well Locations: Year 13"). These figures are included below in ADEQ Response Figures.

Excelsior also did not interpret the pump tests accounting for~~according~~ vertical connectivity or use available core holes to determine connectivity of wells within the proposed well field and formation beneath well field. As noted, coreholes had been completed to as much as 2400 feet bgs. During the pump test, Excelsior missed an opportunity by not recording the response within those deep wells. The application presents no information or evidence regarding the potential for pumping the injection/collection wells on groundwater beneath the site. This could be important because the formations and groundwater at depth are sulfide

- Excelsior should complete at least one longer term pump test using the higher producing wells and monitoring these wells both within the well field, outside the well field and beneath the well field. This would provide improved evidence regarding connectivity throughout the aquifers near the project site.

- The top 200 feet of the sulfide zone have been included in the aquifer exemption, at the request of EPA, to address the possibility of connections to the deeper bedrock.

- ADEQ had the following response to this comment as part of the APP Responsiveness Summary (ADEQ Comment #6.3):

  ADEQ considers aquifer testing conducted by Excelsior to be adequate. Most of the alluvium at the mine site is unsaturated. Small portions that are saturated are only thinly saturated, isolated and will not be affected by injection/recovery activities. Excelsior conducted two aquifer tests in the underlying sulfide bedrock aquifer which indicated much lower hydraulic conductivities (both 0.001 feet per day (ft/d)). Based upon this data, the APP did not include groundwater monitoring within the sulfide bedrock aquifer.

Most of the storage coefficients from tests near the proposed well field indicate confined conditions, although there are exceptions usually on one or more of the observation wells for a given test. Storage coefficients indicate how much water would be released from storage due to a change in pressure within the aquifer. The values vary over~~as much as~~ six orders of magnitude which indicates great variability and that no average value should be applied over the entire model domain. Storativity probably varies among bedrock type and among the fracture density, thus no estimate will be accurate for the entire domain. This is a critical problem for the modeling because storativity controls the amount of water that would be released for a given change in potentiometric surface.

Estimated porosity values from pump tests are minimum because drawdown at the observation wells had not come to equilibrium (Attachment A-3~~CCA 2016~~, p 29~~5-14~~). Excelsior also used gamma-gamma logs to estimate porosity for each 0.1 feet down the wellbore (CCA 2016),~~,~~ but presented~~presents~~ only a weighted average for seven wells and determines only an overall estimated porosity of 2.7% (Attachment A-3, p 29). [redacted]

intact
bedrock. Presenting graphs of how porosity varies vertically along the wells would illustrate the
vertical variability and the potential for preferential flow. The more variable a formation is in the vertical direction, the more potential there is for vertical flow paths and the less potential there is for a hydraulic barrier formed by pumping wells to prevent water from escaping the well field.

- As part of the sensitivity evaluation of the Gunnison model, simulations were completed which substituted a 50 foot per day hydraulic conductivity value in zones with a fracture intensity of 4 (instead of the 10 ft/d simulated). Higher flow velocities would accompany higher estimates of K. Additionally, lower porosity values of 0.5 and 0.8 times the originally simulated values (see tables 10 and 11 Attachment A-2) were evaluated to assess the assumption of higher flow velocities resulting from lower porosity. These analyses were used to see what affect that higher conductive pathways would have on the proposed hydraulic control system. Particle tracking was conducted to determine whether and when the intermediate monitor well network might detect excursions under accelerated flow conditions. The results indicated that containment and capture will be maintained even if model assumptions of K and porosity result in fluid velocities that are too low. Further, the simulations indicate that adequate time has been allotted for the intermediate well network to detect excursions early enough to allow adjustment of operations to reverse an excursion. These results are discussed in Section 4.9.1 of Attachment A-2 of the revised UIC Application.
- The 2.7% estimate of porosity from gamma-gamma logs was simply used to estimate rinsing volumes for wellfield closure. At closure, rinsing will continue until AWQSs and MCLs are met.
- ADEQ responded to this comment in the responsive summary (ADEQ Comment #6.4) as follows:

  The groundwater model did not contain single values for storage coefficients for each formation. Table 10 of Appendix I indicates the estimated storage coefficients and porosities for each type of geologic formation within the model domain based upon the fracture intensities observed from cores. As noted in ADEQ response to Comment #6.2 and #6.3, there is no evidence that the vertical flow is greater than horizontal flow or that the hydraulic barrier created by the HCW would not be effective. In addition, the IMW network is designed to increase monitoring between the active mining block(s) and the HCWs, with contingency requirements for additional HCWs, if needed.

Summary

The hydrogeology of the area shows a very heterogeneous, anisotropic aquifer, with variability being maximum at the proposed well field. [redacted]

[redacted]

Mapping of the groundwater contours is based on a paucity of wells, and is likely inaccurate in areas. The location of the divide could easily be further north placing part of the project site south of the divide.

Mapping of the groundwater contours also assumes there is vertical homogeneity through the site in the potentiometric surface. [redacted]

The groundwater divide is very flat, and just south of the divide the regional gradient is more south and southeasterly than north of the divide. This would direct contaminants that cross the divide towards Dragoon.

Three things could change the location of the divide and cause more flow in a southerly direction. First, pressure from injection at the project site could cause southerly flow, especially if a recovery well is not located in a connected fracture zone. Second, pumping in wells near Dragoon could increase the southerly component of the gradient, especially through preferential pathways. Third, drought could decrease recharge west of the site and lower the contours thereby changing gradients and the location of the divide.

- The groundwater divide is irrelevant to hydraulic control and is not an element of BADCT, nor will it be relied upon to contain solutions. The groundwater divide was simply identified as part of the overall hydrogeologic characterization of the site, as required in the permitting process. The operation of the wellfield, including hydraulic control pumping, maintenance of inward gradients, overall net extraction, and monitoring at observation wells and intermediate monitor wells is the mechanism by which southward migration is prevented.
- Because of the steady-state nature of the hydraulic system, large vertical gradients are very unlikely, and it is not reasonable to assume their presence. The only vertical gradients that are plausible in a steady-state hydraulic condition would be due to limitations on vertical flow of recharge, which is much more likely in a layered geologic condition.
- As stated by Tom Myers in a Technical Memorandum to Amerind Foundation dated September 25, 2017:

  The larger question is this: what do we get from an appeal hearing? We are not going to show that the mine is a threat to Dragoon-area groundwater, simply because the flow gradients are to the east, not towards the community or its well. We do not have evidence to show their potentiometric surface maps (flow direction) are so wrong that the flow is actually toward Dragoon. That means I do not think we could get the project denied. The best we would get is a few more POC wells. I do not recommend an appeal because it is a huge effort for very little real potential gain.

Excelsior modeled the regional hydrogeology using a groundwater flow model based on the MODFLOW code. The model was reviewed, and the review is included as the bottom section of this document.

Water Chemistry

The groundwater is generally a calcium-sodium-magnesium-bicarbonate type with TDS varying from 210 to 420 mg/l, with some high fluoride concentrations. Samples from the sulfide zone are sodium-carbonate-bicarbonate or sodium-bicarbonate-chloride-sulfate with higher TDS (p
5-6). Metals are generally low but there were some hits of volatile organics. ~~Excelsior reported petroleum products in the groundwater on the project site. Coreholes CS-10 and CS-14 had~~

Excelsior reported petroleum products in the groundwater on the project site. The following discussion of petroleum contamination is based on the discussion in the UIC application (CCA

2016), because no discussion of petroleum contamination was found in the UIC documents. Coreholes CS-10 and CS-14 had free petroleum product in the groundwater, which means there is LNAPL (light, non-aqueous phase liquid) floating on the surface of the water (Figure 54). After pumping it from the corehole, it reappeared and was 0.25 feet thick in about ten days (CCA ~~2017a, p 5-8). That indicates there is a significant source of LNAPL near the site. The clustering of wells with~~

2016, p 5-8). That indicates there is a significant source of LNAPL near the site. The clustering of wells with different hydrocarbons, as seen by the distribution of hydrocarbons in Figure 54, may reflect different transport and attenuation rates for the different products within the fracture zone affected by the source. The intermixed wells without any hits may be screened in different fracture zones.

- *ADEQ response to Comment #6.5*
  ADEQ does not consider petroleum hydrocarbons a significant issue to liner performance, SX-EW performance or additional impacts to the aquifer. Based upon Excelsior's response to ADEQ comments in June 17, 2016, the hydrocarbons appear to be related to old drilling methodologies which used petroleum fluids during drilling and residual contamination from the former Leaking Underground Storage Tank (LUST) release from "The Thing" near the southwest corner of the site. Mining will extract any remnant hydrocarbons which will then be processed with the other extracted fluids.

- Excelsior's responses to ADEQ's comments regarding LNAPL occurrences are provided below:

ADEQ COMMENT: Section 5.4, Groundwater Quality

In the course of monitoring, Excelsior detected petroleum odors in these and other coreholes, and free product in CS-10 and CS-14. Samples were collected as part of a study of Light Non-Aqueous Phase Liquids (LNAPLs) in groundwater by Haley & Aldrich (2015).

a. Please provide additional information regarding the lateral and vertical extent of the petroleum plume in the groundwater per A.A.C. R18-9-A202(A)(8)(b)(vi and vii).
b. Please provide additional information regarding your plan in addressing and determining the source of the petroleum contamination in the groundwater per A.A.C. R18-9-A202(A)(8)(b)(vi and vii).
c. Please provide additional information regarding the impact of mixing and injecting petroleum contaminated water to the aquifer per A.A.C. R18-9-A202(A)(8)(b)(vi and vii).

RESPONSE:

a. Excelsior does not have additional information regarding the lateral and vertical extent of the petroleum "plume". However, based on the chemical data presented in Table 5-5 of the APP Application and the Haley & Aldrich report (Appendix E of the APP application), a conceptual model is proposed in which there are two distinct sources of petroleum:

1. Drilling fluids, including diesel or some other petroleum product in CS-10 and CS-14. LNAPL, benzene, toluene, ethylbenzene, xylenes, and polycyclic aromatic hydrocarbons (PAHs) are present in these coreholes.
2. Gasoline compounds (primarily benzene, toluene, and 1,2 dichloroethane—a lead scavenger) from leaking underground storage tanks at "The Thing" (ADEQ LUST ID 4387). ADEQ closed the site in May 2005.

Regarding source #1, at CS-10 and CS-14, the most likely source of LNAPL and the hydrocarbon compounds detected in these coreholes is from the drilling fluids used to drill the borings. The following lines of evidence support this conclusion:

- Both of these coreholes were drilled in 1971. According to Ron Peterson (personal communication), a mud engineer at Halliburton, it was common practice at that time to add diesel or any inexpensive, available petroleum product to drilling mud to lubricate the drill rods and, if necessary, get them unstuck. As noted by Haley & Aldrich, the compounds detected in CS-10 and CS-14 are consistent with a mixture of petroleum products, including gasoline. Drilling mud technology has advanced significantly since that time, and the advanced polymers used now are more effective and environmentally friendly.
- LNAPL was not observed in any of the NSH wells drilled in 2014-2015, the nearest of which are 150 and 300 feet away (SHH-10, NSH-13, and NSH-14B).
- In February 2015, after LNAPL was discovered in CS-10 and CS-14, Haley and Aldrich returned to the site on a weekly basis to measure and bail LNAPL. They were able to remove all of the LNAPL from CS-14 and remove all but a very thin layer at CS-10. If a thick layer of LNAPL of significant lateral extent were present, LNAPL would continue to enter the hole and bailing would not have reduced the thickness.
- The extent of petroleum in CS-10 and CS-14 appears to be limited to the immediate area of the boreholes. The wells nearest to these borings (NSH-13 and NSH-9, respectively) do not contain LNAPL.
- There are no known prior site uses that would result in the LNAPL occurrence observed in these borings.

Regarding source #2, dissolved petroleum compounds have been detected in NSH-15, NSH-16, and NSH-17 in the southwest corner of the wellfield just downgradient of The Thing USTs. The wells are screened from depths ranging from 585 to 820 below ground surface (NSH-15), 580 to 820 below ground surface (NSH-16), and 940 to 1181 feet below ground surface (NSH-17). VOC concentrations are below AWQSs.

Toluene was detected in most of the NSH wells sampled in 2015. In most cases, toluene was the only compound detected. Detection of toluene in new monitor wells is common, and it is believed to be from the adhesive on the pipe wrap tape that was used on the pump and wiring (Christy's© Pipe Wrap Tape 10ml has 1.3% by weight toluene in the adhesive). Using toluene concentrations to evaluate the extent of a petroleum plume is not recommended for this reason. It is notable that the three wells that could not be pumped for very long before being dewatered, NSH-25, NSH-14b, and NSH-22, had some of the highest toluene concentrations. This supports the pipe wrap tape as a source—the well could not be adequately flushed. The other wells could be purged of significant volumes before samples were collected, so toluene concentrations were low to non-detect.

In summary, the extent of petroleum compounds in groundwater is limited to the southwest corner of the wellfield as a result of leaking underground storage tanks at The Thing, and in the immediate areas of CS-10 and CS-14, as a result of past drilling practices.

b. Excelsior does not intend to conduct an investigation of the source of petroleum in groundwater because the source(s) are not ongoing, the contamination is pre-existing, and the small quantity of organic compounds is considered a *de minimus* condition. In addition, it will be removed in the copper recovery process.

c. The solvent extraction-electrowinning (SX-EW) process mixes extracted, copper-bearing solutions (PLS) with a petroleum liquid (organic phase) as an essential part of the copper recovery process. Any petroleum compounds recovered from the wellfield in PLS, will be routed to the PLS pond and then to an extraction-stage mixer-settler. In the mixers, the PLS is thoroughly mixed with an active organic extractant in an organic liquid (similar to kerosene), forming a copper-organic complex. Petroleum compounds in the PLS will strongly partition into the organic phase and be separated from the aqueous phase in the settler. Each of six settlers has at least 1,800 square feet of area in which the organic phase is exposed to the atmosphere for volatilization of entrained BTEX compounds. The barren aqueous phase (raffinate) is routed to the raffinate pond for retention and further separation of the organic and aqueous phases. An oil skimmer in the raffinate pond will remove residual organics. The raffinate is pumped from the bottom of the raffinate pond, re-acidified, and recirculated in the wellfield. Although not intended for this purpose, the SX-EW process will be an effective way of removing any petroleum compounds from solution before it is re-injected into the aquifer. However, as discussed in part a of this answer, the extent of petroleum compounds in the wellfield is limited, and based on the characterization completed to date, Excelsior does not anticipate encountering LNAPL or significant concentrations of dissolved petroleum in the wellfield.

ADEQ COMMENT: *Section 5.4 (Groundwater Quality)*

Several PAHs were detected in the LNAPL samples from coreholes CS-10 and CS-14 where free product had been recovered.

Per A.A.C. R18-9-A202(A)(8)(b)(vi and vii), please provide information regarding the source of the PAHs in the groundwater. Also, please provide information regarding the lateral and vertical extent of the PAHs plume.

RESPONSE:

Regarding the source of PAHs detected in LNAPL from coreholes CS-10 and CS-14, as discussed in Appendix E of Excelsior's APP application and in response to Comment 3, above, LNAPL was detected in these coreholes. According to Appendix E, Haley & Aldrich collected investigative (no purging) samples of groundwater using a bailer to determine the concentrations of dissolved volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). In addition to benzene, toluene, ethylbenzene, and xylenes (BTEX), several PAHs were detected.

The most likely source of LNAPL and the hydrocarbon compounds detected in these coreholes is from the drilling fluids used to drill the borings. The following lines of evidence support this conclusion:

- Both of these coreholes were drilled in 1971. According to Ron Peterson, a mud engineer at Halliburton, it was common practice at that time to add diesel or any inexpensive, available petroleum product to drilling mud to lubricate the drill rods and, if necessary, get them unstuck. As noted by Haley & Aldrich, the compounds detected in CS-10 and CS-14 are consistent with a mixture of petroleum products, including gasoline. Drilling mud technology has advanced significantly since that time, and the advanced polymers used now are more effective and environmentally friendly.
- LNAPL was not observed in any of the NSH wells drilled in 2014-2015.
- In February 2015, after LNAPL was discovered in CS-10 and CS-14, Haley and Aldrich returned to the site on a weekly basis to measure and bail LNAPL. They were able to remove all of the LNAPL from CS-14 and remove all but a very thin layer at CS-10. If a thick layer of LNAPL of significant lateral extent were present, LNAPL would continue to enter the hole and bailing would not have reduced the thickness.

The data do not indicate that there is a plume of PAHs at the site associated with LNAPL. We propose a conceptual model in which PAHs associated with LNAPL in CS-10 and CS-14 are limited to the boreholes and the immediate area, where petroleum was apparently introduced when the holes were drilled. Any PAHs entrained with the recovered PLS would partition into the organic phase during solvent extraction and be removed from the raffinate because PAHs are not soluble in the aqueous phase.

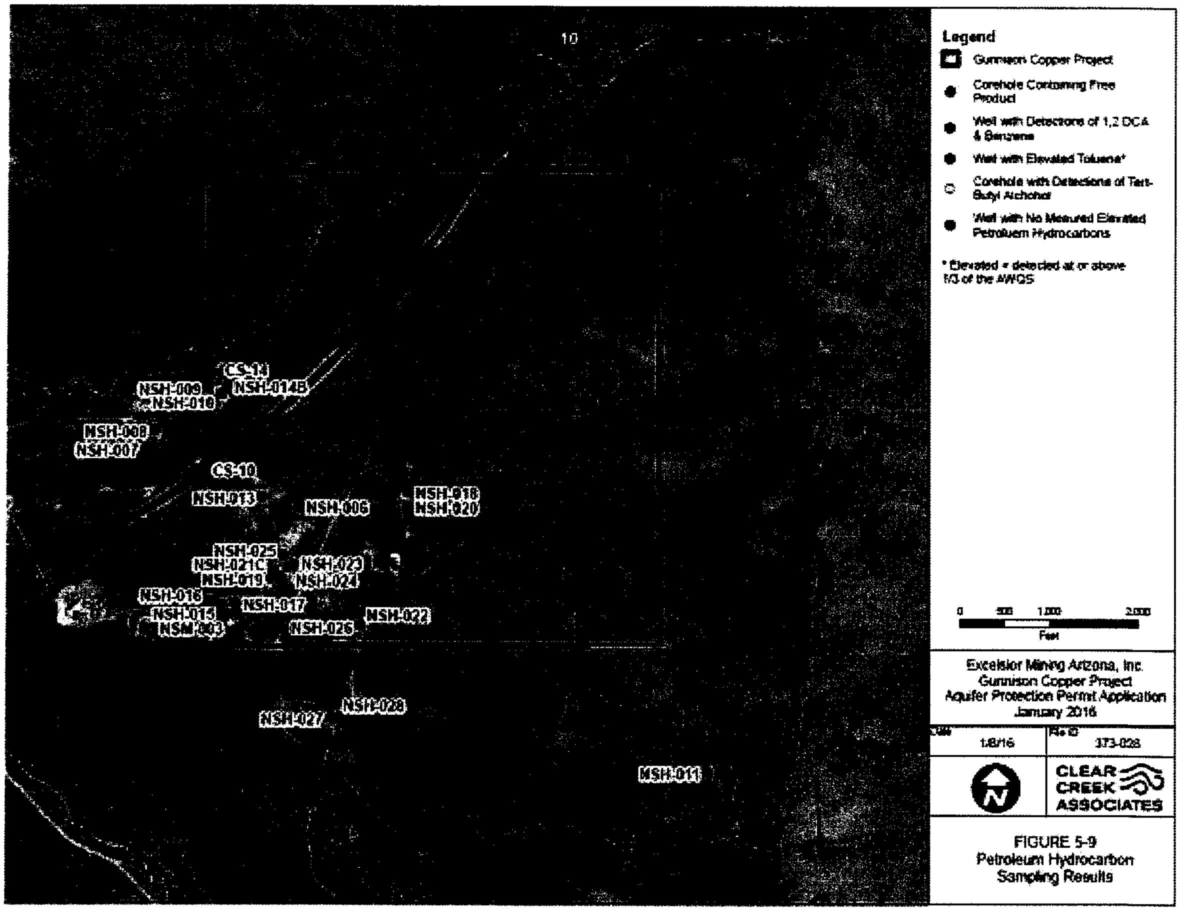
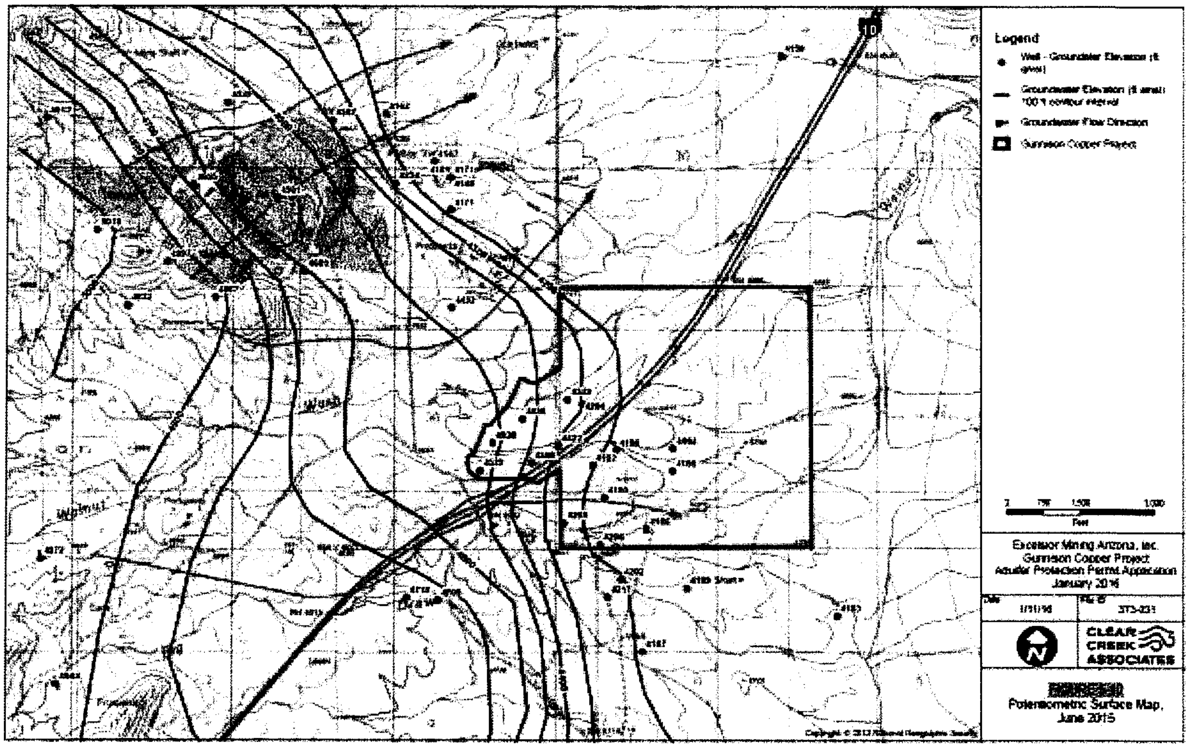


Figure 54: Figure 5-9 from Clear Creek Associates (2017a) showing the wells and coreholes with petroleum hydrocarbon hits.

Excelsior explains the potential sources are The Thing gas station and the Johnson Camp Mine, although the mine may not have stored petroleum products (CCA 2016, p 5-9). The Thing site had underground storage tanks removed in 1996 because there had been contamination detected in the soil. ADEQ closed the case files investigating the contamination between the substantial depth to groundwater (hundreds of feet) and the presence of bedrock just two feet below the tanks. Most of the detections (Figure 54) are potentially downgradient of the Thing site (Figure 25). If indeed The Thing is the source, there has been substantial transport and lack of attenuation, which could be a significant source of contamination to the project.



~~*Figure 5: Figure 5-10 from Clear Creek Associates (2016) showing the potentiometric surface at the site and to the west and northwest.*~~

As noted, the mine apparently did not use gasoline, so Excelsior seems convinced that it could not be a source (CCA 2016, p 5-9). They also point to the gradients of the potentiometric surface which suggest that groundwater flow from the mine would be to the northeast and would miss the project site by a mile or more. The potentiometric surface (Figure 2~~5~~) appears to drop steeply northeast of the mine and appears to form a ridge on the west side of the project site.

- Due to the importance of understanding the source of petroleum products, Excelsior should reconsider the potentiometric surface map to consider whether the water levels used for mapping all represent the same aquifer level. In a fractured rock aquifer, it is not often appropriate to assume there are no vertical gradients. The map with water level with respect to the top of the bedrock (Figure 5-12, CCA 2016a) shows significant variability in small areas, suggesting that it is possible the water levels represent different bedrock levels. It is possible that groundwater flows southeast from the mine at certain levels. For this reason, the mine cannot be ruled out as a source.

- ADEQ response to Comment #6.6
  Please see response to Comment #6.5.

- Hydrocarbons in the groundwater could affect the chemistry of the project. Excelsior must complete a larger survey of the LNAPL contamination and assess whether and how it could affect ISL operations.

- *ADEQ response to Comment #6.7*
  Please see response to Comment #6.5.

Copper Mining Project

The project is an in-situ leach and recovery project for copper in the bedrock formations underlying the basin fill at the site. The project involves injecting an acid solution into the groundwater of the bedrock aquifers so that it can leach Cu which would then be recovered in capture or collection wells. The project involves the construction of various ponds and a solvent-extraction electrowinning plant (SX-EW plant). The SX-EW plant would be at the Johnson Camp mine during phase 1 and then just east of the mine in phases 2 and 3 (the second ten years of the 20-year project life) (Fact Sheet, Clear Creek Associates 2016, p 1-4). The site plan (Figure 6) only shows the SX-EW plant at the mine site.

Figure 6: Facility site plan, from Figure 1-2 (Clear Creek Associates 2016)

The well layout would have four collection wells surrounding each injection wells. However, the map of the well field (App I, Figure 44, shown below in the review of groundwater modeling as Figure 18~~17~~) shows a 5-spot well pattern that shows that each collection well would be part of the four collection wells for at least four injection wells. The development blocks (App I, Figure

45) indicate that sections of the well field would be developed such that 5-spot patterns would overlap with adjacent 5-spot patterns which would cause the 4:1 collection to injection well ratio to not hold throughout the project life.

- *ADEQ response to Comment #6.8:*
  As discussed throughout the application and response to ADEQ comments, the 5-spot pattern is the base design for in-situ mining. In Stage 1, 200 injection/recovery wells are planned to be constructed. Each 5-spot is planned to be part of other 5-spots. For example, each of the recovery wells for one 5-spot will be recovery wells for the adjacent 5-spots. Therefore, the recovery well to injection well ratio will vary, as planned, over the life of the mining operation. The ratio of the amount of fluid injected to the amount of fluid recovered in each mining block will remain approximately 1:1.

The injection rate would vary with time throughout the project life (Attachment K~~CCA 2016, p 7-5~~). Total rates range from 5300 to 25,600 gpm with the lower rate for the first ten years (Draft Permit, p 16). They also propose to limit pressure applied according to the formation type, with a 0.9 factor~~75 psi/ft~~ of safety (Draft Permit, p 21).~~screen length.~~ The actual injection rate would depend on the pressure, but there is no discussion of that. Pressure is limited to avoid fracturing the rock. However, the pressure necessary to fracture a formation is likely very variable, and there is a possibility that the factor of safety would be insufficient in some areas. Fracturing could connect previously unconnected fractures and preferential flow zones allowing fluid to escape the project area through unmonitored fracture zones.

- The fracture gradient testing methodology used to arrive at the permitted pressures was extensive and conservative. The 0.9 safety factor makes the permit values even more conservative. Actual flow rates will depend on the pressure. Excelsior will comply with the maximum pressure and maximum injection rates allowed by the permit.

The injection/collection process would collect more water than is injected, which should cause a general drawdown within the well field.

- Injection and recovery in the wellfield are intended to be equal. The Hydraulic Control wells will cause drawdown at the perimeter of the wellfield to provide hydraulic containment. The statement is incorrect.

A line of collection wells, known as hydraulic control (HC) wells, would surround the well field and be designed to withdraw water and create a trough in the potentiometric surface intended to prevent water from within the wellfield from escaping from the wellfield. Predicted drawdown from HC~~hydraulic control~~ wells would extend to the east of the well field by 1200 to 1500 feet from the control wells at maximum pumping based on

~~1200 to 1500 feet from the control wells at maximum pumping based on~~ modeling (Application, p 5-15). Also, modeling suggests drawdown would never exceed 50 feet (Id.). There is no guarantee that these wells would intercept flow in each preferential flow path.

- Aquifer testing has demonstrated a high degree of connectivity within bedrock due to faulting, fracturing, and bedding plane pathways. While hydraulic control wells will be placed to intersect major pathways, it is not necessary to intersect each flow path to contain solutions. The drop in pressure within fractures is sufficient to contain solutions in all fractures around hydraulic control pumping, even for those fractures not directly intersected by a hydraulic control well. Fractures form a network of interconnections therefore lowering the pressure in one of the interconnected fractures necessarily reduces the pressure in all fractures in the network.

As described below in the groundwater modeling section, the model uses model cells with averaged material properties, so estimated drawdown is an average for the cells that does not account for preferential flow paths. The model does not consider the potential for ~~fractures to transmit flow and contaminants from the well field. The modeling includes MODPATH simulations which are described below in the Groundwater Modeling section.~~ fractures to transmit flow and contaminants from the well field. The modeling includes MODPATH simulations which are described below in the Groundwater Modeling section. The use of HC wells as monitor wells is discussed further in the monitoring well section below.

- *ADEQ response to Comment #6.9*
  Please see response to Comment #6.2 on the comment about the influence observed by aquifer testing conducted by Excelsior and what their interpretation indicated about preferential flow paths. In response to the comment about injection pressure, the rate of 0.75 psi/ft takes into account depth of the well to avoid fracturing the rock. The overall injection rate is determined by the processing facilities capacities, not by injection pressure. Each well operates below the fracture gradient pressure and overall flow is adjusted by the number of wells and flow restriction valves.

The system works by injecting acid-rich barren solution into the ore-bearing aquifer. The low pH leachate would dissolve copper, and other metals from the ore. The processing of the pregnant solution would remove copper, after which the solution would be recycled to be used for leaching again. Acid would be added to lower the pH once again before being reinjected into the ore body. The processing of copper would allow most other metals to remain in solution, so that the water being circulated through the system would have concentrations of metals and some anions that are multiple times their water quality standards. Concentrations of cadmium, lead, selenium, nickel, thallium, zinc, and fluoride,

among others, would be orders
of magnitude higher than background levels and most water quality standards (CCA 2016, Table 6-1, Appendix J-3). The incredibly poor water quality of the leach solution exemplifies why preventing any of it escaping the system is critical.

Excelsior argues this site is favorable for "maintaining control of the leach solution" (Application, p 7-2) because there are no drinking water aquifers, or underground sources of drinking water (USDW) above or below the zone of injection, and there is limestone within and downgradient of the wellfield which would provide a large attenuation capacity. The well field would be sandwiched between mostly unsaturated basin fill and a mostly low permeability sulfide zone below. The application presents evidence that the potentiometric surface is above the base of the alluvium in some areas which would confirm the target zone is a confined aquifer, which means pumping it would have little effect on water levels in any saturated layers above the target zone. The underlying sulfide zone has low conductivity, as confirmed with two pump tests which at 1 and 4 gpm caused substantial drawdown.

Excelsior's claim regarding downgradient attenuating formations is too broad with respect to the downgradient Escabrosa and Horquilla limestone because they fail to consider how much of the amount of neutralizing carbonate rock would actually contact any acid escaping the well field. If acid escapes and contacts the limestone much of it could be neutralized, but only if the acid solution actually contacts the limestone. If the acid solution preferentially flows through fractures in the limestone, it may use much of the carbonate within the fractures so that the remaining acid would flow through without actually contacting the neutralizing limestone. Analyses that simply show the limestone has sufficient neutralizing capacity, such as Appendix J-1, but do not assess the flowpaths through the limestone, cannot prove the downgradient formations are an adequate buffer. The limestone should not be relied on to neutralize acid that reaches it unless there is an accounting for the effective neutralizing capacity of in situ limestone.

- Excelsior should provide a realistic assessment of attenuation capacity considering the amount of limestone that escaping acid solution would contact.

- The geochemical model (Attachment H-2) does indeed consider how much of the acid solution contacts the limestone through a factor called the water:rock ratio. According to Attachment H-2, "The water:rock ratio in a fractured system is a function of the secondary (or fracture)porosity of the bulk rock (which provides the volume of fluid available for reaction) together with the surface area of mineral exposed on the fracture surface and the depth of the reaction zone (which together give the volume of mineral available for reaction)." Refer to section 4.2.3 of Attachment H-2 for more about the water:rock ratio.

- ***ADEQ response to Comment #6.10***
  Please see response to Comment #6.2 as it relates to preferential flow paths. In evaluating the neutralizing potential of downgradient limestone, the geochemical model took into account the estimated secondary porosity of 3% for the downgradient limestone.

The injection/collection well fields would be rinsed after the copper has been removed to flush the contaminants from the aquifer and the groundwater. The plan includes rinsing with three pore volumes of freshwater (Stage 1), followed~~follow~~ by rest for one year (Stage 2), followed by rinsing with two more pore volumes (Stage 3) (Draft permit~~CCA 2016~~, p 39~~7-11~~). The rest period allows the latent solution to reside in the pores where ongoing neutralization would occur. They estimate this would require a year. The injection/collection wells no longer being used would be abandoned and closed. The standards for determining when rinsing is done are water quality standards in random samples (Draft permit, p 40). [redacted]

[redacted]

- ***ADEQ response to Comment #6.11***
  The permit requires continued rinsing until constituents with aquifer quality limits (AQLs) return to permit requirements. Please note rinsing is proposed to occur in three stages for each mine block.

- [redacted]

- The permit does not specify a number of pore volumes for rinsing, as stated above. Specifically, the draft UIC permit says, "The groundwater in the injection and recovery zone shall be restored to concentrations which are less than or equal to primary MCLs defined at 40 CFR Part 141, or to pre-operational background concentrations if the pre-operational background concentrations exceed MCLs. "

The draft permit calls for a five-year post-rinsing monitoring period, but there is no description of the goals of that period. Most wells would be abandoned, so it is not clear what could be done. ~~does not establish the standards referred to as rinse verification standards. Table 4.1-7 in~~ the draft permit should outline a strategy for remediation durin~~specify standards but only has "monitor" or "report".~~

- ~~The APP should specify~~ the post rinsing perio~~d numeric standards to which rinsing will be continued upon closure~~

- During the post rinsing period, monitoring will be conducted at POC, outer OWs, and CVWs (closure verification wells). Closure standards must be met for five consecutive years before post-closure monitoring is complete. This is the same requirement in the APP. *Section 2.9.1.2 of the APP indicates that when all Closure Verification Wells (CVW) have met rinse verification standards for five consecutive years, monitoring may stop and all wells (Rinse Verification Wells (RVWs), CVWs, HCWs, Observation Wells and POC Wells) may be plugged and abandoned. This condition is protective, as it requires no exceedances of AWQSs, or ambient conditions if AWQSs are exceeded during post-closure monitoring, within the wellfield and the Observation Wells. This requirement will ensure that there will not be an exceedance in the POC Wells after the end of the post-closure groundwater monitoring period.*
- *ADEQ response to Comment #6.12*
APP typically allows for ambient conditions to be evaluated after Individual APP issuance. The APP contains language in Sections 2.5.3.1.2, 2.5.3.2.1, and 2.5.3.3.1 to conduct ambient groundwater monitoring along with compliance schedule items in Section 3.0 that specify when the permit is to be amended to set alert levels (ALs) and AQLs.

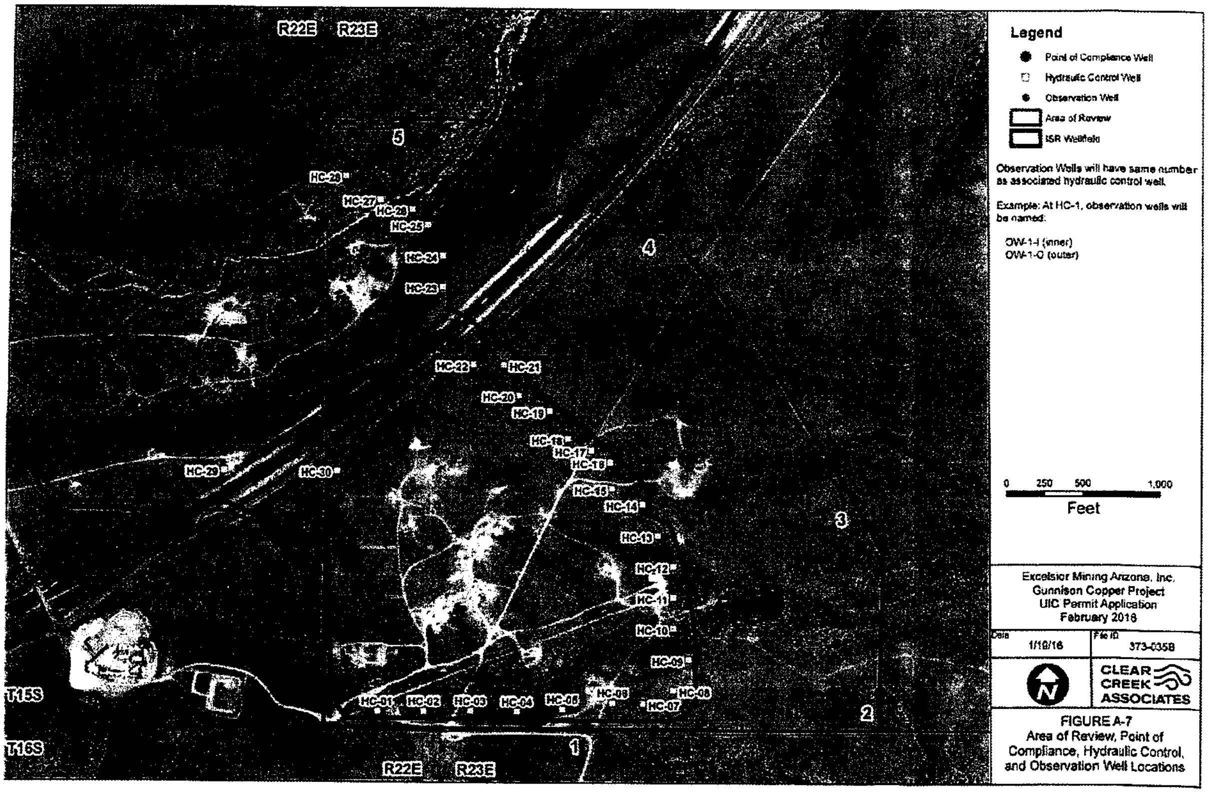
Monitoring **Wells**~~*the Project*~~

If the well field operates properly and there are no fractures connected to injection but not recovery wells, the project would not contaminate offsite groundwater. However, even if monitoring wells show a 1% inward gradient, it is possible for fluids to escape ~~The Gunnison Copper Project would utilize three types of wells to maintain and monitor~~ hydraulic control through preferential flow pathways.

Groundwater monitoring wells are necessary to verify that the project is operating properly, since a significant change in gradient around the site or changes in specific conductivity or other contaminant would identify the problem. For this reason, the monitoring well layout is of utmost importance. Also, the monitoring wells must be designed to protect potential incursions offsite to groundwater users in the area. The draft permit (p 6) claims there will be 30 HC wells, 22 observation wells (OW), 30~~:~~ Intermediate Monitoring Wells (IMW), and five point-of-~~Observation Wells (OW), and Hydraulic control wells (HCW). The project would also deploy Point of~~ Compliance (POC) wells. ~~outside the area of hydraulic control to detect contamination migrating away from the site. While the IMW, OW, and HCW wells are critical in controlling and monitoring mining operations, the~~ POC wells would be constructed along an outer ring, so they would be the last monitoring wells to detect ~~provide the best indication of~~ contaminants leaving the project site. There will also be up to 120 rinse-verification monitoring wells (RVW) (Id.). These will monitor up to 1400

Class III injection and recovery wells constructed through the project site (Id.).

Figure 7, Figure A-7 from the draft permit, shows the HC, IMW, and POC wells for the site. The OW wells show as green circles without labeling; some of them plot underneath the yellow squares showing HC wells, so the figure is not perfectly clear. There are three pairs of OW wells and seven HC wells across the southern boundary of the well field, or about 2000 feet. Most remaining HC wells spread along the east and northeast boundary of the site, about 4000 feet, with two HC wells on the west. There are seven pairs of OW wells on the east and one pair on the west (Figure 7). Not all wells would operate simultaneously, however. Draft permit, Appendix A, Figures A-7a, A-8, and A-13 through A-16, show the monitoring wells as operated for given time periods. [redacted]



<u>Figure 7: Figure A-7</u>~~migrating away~~ from the ***<u>draft permit, Appendix A, showing the project area and location of hydraulic control wells, observation wells, and point-of-compliance wells.</u>***

As described above, there are multiple pathways and scenarios which could lead to contaminants escaping the hydraulic control of the site. The monitoring well scenario described within the draft permit is insufficient to protect offsite resources, including wells near Dragoon. This violates requirements for monitoring wells outlined in 40 CFR 146.32(h), which requires spacing based on an assessment of geology.

- The monitoring network, including HC and OW wells, meets the requirements of 40CFR 146.32(h). The HC and OW wells were sited based on the groundwater model AND the geologic and structural models. To check the locations, particle tracking was done which demonstrated that all particles are captured before they could exit the wellfield, indicating these wells are properly located. The IMWs provide an additional level of monitoring within the wellfield. They are expected to eventually be impacted by mining solutions as mining advances.
- Both the APP and UIC permits require that Excelsior periodically review the model given new data obtained during operations. Both permits (APP: Table 3.0-1, Compliance Schedule Item 20; UIC: Part II, paragraph J, Operation and Post-Rinsing Audits) require that "within six (6) months of completion of the first year of operation for each of the three stages and every five (5) years thereafter for Stages 1 and 3 until mine closure", the operator will issue a Groundwater Flow Model Evaluation and Update Report that describes revised calibration and future projections.
- Periodic updating of the model will also allow adjustments to IMW, HC, and/or POC wells. The updated model will be used to appropriately locate IMWs beyond year 13 through the incorporation of operational experience and data.

HW and OW wells surround the immediate project site, as shown in Figure 7. HC wells would surround the project site and are pumped to create a trough in the water table to capture any water escaping the project and to assure that flow is toward the project. There would be up to 30 such wells, although not all would operate at the same time, with operations based on which sections of the project are being processed at any given time. The amount of water pumped from them would cause total project recovery to exceed total injection by 1%. Fluids pumped from the HC wells would be monitored for SC, so if these wells capture any project lixiviant, SC would spike. Twenty-two paired OW wells (11 pairs) would monitor the gradient, which is intended to be inward, with inward meaning that groundwater levels outside the project would exceed those inside the project. The OW well pairs must demonstrate a 1% gradient toward the well field.

The gradient measured by the OW wells as designed could meet the standard but there could be zones within the monitored rock with gradients away from the project. The water level in an OW well would rise to a transmissivity-weighted average of all productive zones within the well. Each productive zone could have its own gradient which could be masked within the OW well. Flow could leave the mine site undetected. The only way to prevent this is to monitor each productive zone separately, which can be accomplished by using the geophysical logging to identify layers in the formations.

- Each OW well should be assessed to determine whether there are different productive zones. If there are substantial differences in fractures or other indicators of differing permeability down the well bore, the permittee should isolate each zone for separate monitoring, including groundwater level and water quality. This is the only way the OW well pairs can adequately monitor the gradient around the site and assure no flow will likely leave the site.

- HC wells should also be considered as to whether they control some flow zones better than others. Pumping wells that span more than one productive zones will withdraw water according to the transmissivity of the various zones. If those zones do not coincide with the well field production zones, the HC wells may not provide the necessary control. The HC wells should have the ability to produce from all productive zones they intersect.

The Draft Permit establishes special consideration for three HC wells established on the southern project boundary prior to year 1 (Draft Permit, p 25). The consideration includes daily monitoring of SC, even though the development is at least 700 feet north of the boundary. This indicates the EPA recognizes the potential for southward flow, but their response is inadequate because the wells would be spaced too widely. [redacted]

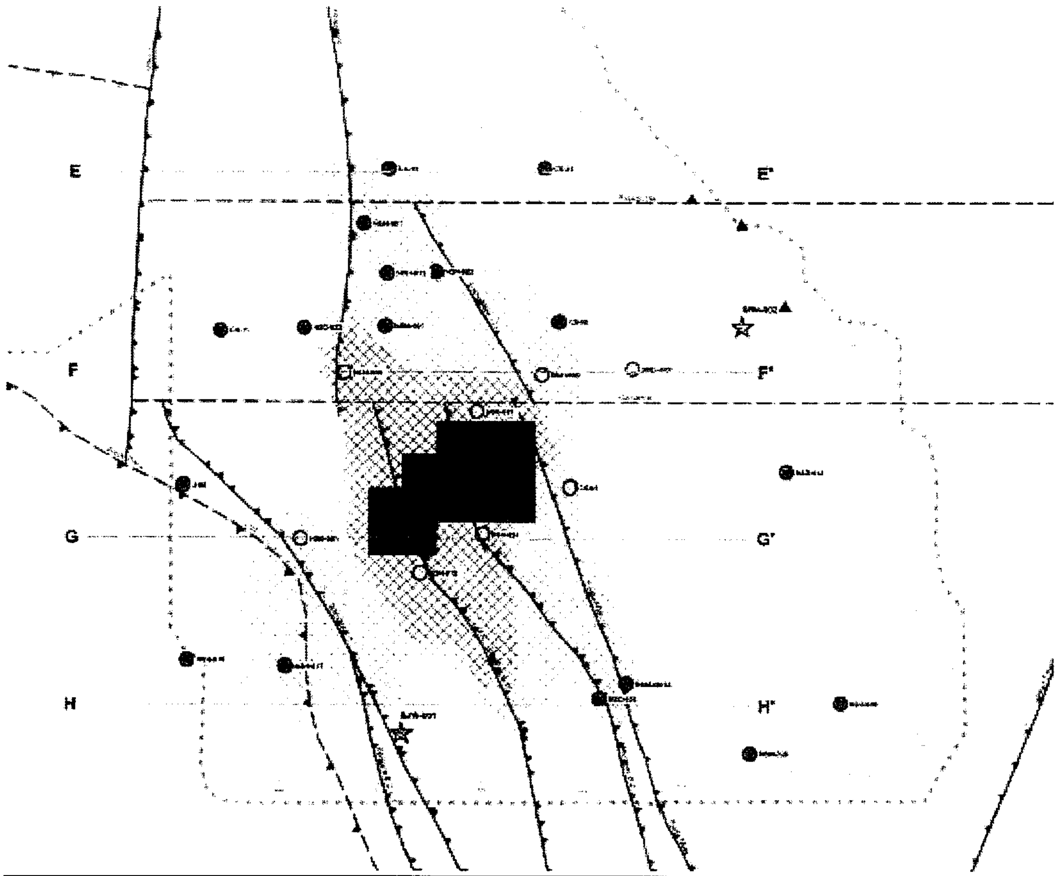


Figure 8: Portion of Draft Permit, Appendix A, Figure A-13 showing the intermediate and HC monitoring well layout for year 1. the green circuls are IMW wells, the trianges are inactive HC wells. The figure shows faults and the project boundary (blue dashed line.

- All six faults or potential fluid channels described by Myers above, and depicted in the figure above, are intersected by one or more of the IMW's. These IMWs are therefore well positioned to detect any release of mining fluids from a mining block.

There would be POC wells to detect whether contaminants are moving off the wellfield.

Excelsior proposed five POC wells located outside the area of review (AOR) (~~CCA 2016, p 5-18)~~ ~~(~~Figure 7). The AOR is roughly the hydraulic barrier created by the hydraulic control wells. The five POC wells are grossly insufficient for two reasons. [redacted] higher and lower than in the aquifer.

- It is quite appropriate to screen the POC wells across the portion of bedrock that is the focus of mining because this zone constitutes the aquifer that must meet AWQS and MCL requirements. A downgradient user is not going to build a well with a screened interval that spans one particular fracture; they would target the entire interval.

Second, five wells spaced along the ~~pollution management area~~ perimeter (Figure 7) is grossly insufficient spacing. Large contaminant plumes could flow between the wells undetected. ~~Also, their placement assumes the potentiometric surface gradient is adequately known to be sure there could be no movement to the south, north, or even west. This is an unsupported assumption because, as discussed elsewhere, heterogeneities and preferential flow paths could cause flow paths that are not perpendicular to the general contours.~~

~~There would also be five POC wells downgradient of the impoundments (Figure 7), intended to detect leaks from those impoundments. POC wells 9 and 10 would monitor along the downgradient side of solids ponds 1 and 2. Having just one well for each of these ponds is insufficient because they would only detect contaminants that leak into a flowpath directly upgradient of the well. The size of these ponds should make obvious there are many areas that could contribute contaminants that would not be upgradient of the POC well. These POC wells would detect contaminants that reach the water table through the unsaturated zone, so the source would be at the water table. They would disperse vertically, but not that deeply. The wells should screen the water table and extend below the water table the minimum possible to be sure that water table does not fall below the well. The 60-foot proposed screen thickness is far too large to adequately detect contaminants at the water table because it would allow for cleaner, deeper water to dilute the contaminants.~~

- The number and spacing of POC wells should be determined by modeling of contaminants being released either within the well field or the ponds accounting for horizontal dispersion. Well-spacing should be less that the width of simulated plumes at the line of POC wells.

- ***ADEQ response to Comment #6.13***
  ADEQ does not agree that monitoring groundwater in the POC wells is the best and most expedient way to determine whether there has been an excursion from the mine blocks. Monitoring from the IMWs and OWs is a much more expedient way to determine whether there has been an excursion and allows for changes of recovery rates and allows the excursion to be recovered. At this time there is no reason to include additional POC wells. For conceptual POC locations related to lined impoundments, wells would only be installed if there was an impoundment failure. The Response to ADEQ Comments dated April 2017, Figure 9-1 "Discharge Impact Area and PMA Boundary" provides a revised evaluation of the discharge impact area (DIA) and revised location of the POCs.

- The POC wells downgradient from the well field should monitor different vertical preferential flow paths separately. That means that at each POC well location, the wells should monitor each potential flow zone. Either nested wells or multiple opening wells could be used. Multiple screened openings along the bore hole no more than 20 feet long would be preferable so that the depth of the contaminant could be determined.

- ***ADEQ response to Comment #6.14***
  At this time, vertical profiling of groundwater at the POC well locations is not warranted or required due to the interconnectivity of the bedrock and the extensive monitoring within the PMA.

The obvious concern for contaminant excursions across the southern boundary indicates additional importance for monitoring the southern boundary of the site. This is the boundary that separates the project from Dragoon, and as discussions above have shown, there is a substantial potential for flow to vary from the regional contours and head south. The UIC should monitor for this by considering the following:

- The HC wells should be fully installed and active at the beginning of mining. This would create a trough in the water table that would prevent excursions, if the pathways are connected to the regional water table.

- Operation of HC wells causes drawdown and an unnecessary use of a natural resource. The sequence of HC well operations has been carefully scheduled to limit both drawdown and excessive pumping of groundwater. The IMW's intersect all of the major fault and bedding plane systems therefore, because travel times are slow, excursions of mining solutions from mining blocks will be detected long before anything reaches the HC well system.

- HC wells should be installed in fracture zones associated with the faults.

- IMW wells intersect all major faults. Table A-2 of the UIC permit lists all of the IMWs and the faults that each individual well intersects. HC wells intersect faults if they are present at the well field boundary but have primarily been located based on model particle tracking simulations to prevent excursions of mining solutions from leaving the wellfield. In some areas, no significant faults are present; nevertheless, HC wells have been sited based on model results. Figure A-13 shows the locations of the mining year block 1 IMW locations in relation to major faults. Note that some of the borings shown on this figure are angled and penetrate various faults at depth.

- The faults should be more fully monitored, with IMW wells situated along each of them.

- IMW wells intersect all major faults. Table A-2 of the UIC permit lists all of the IMWs and the faults that each individual well intersects.

- POC wells on the south boundary should be outside the boundary created by the HC wells. This is necessary to monitor for contaminants not captured by the HC wells. The ~~• The POC wells below the ponds should span the water table to adequately monitor contaminants that could reach the water table. The screen length should be the minimum possible to avoid the water table dropping below its bottom~~

- POC wells are located outside of the HC wells and are positioned based on model predictions of groundwater flow in and around the boundary.

~~•~~ POC wells should be about 300 feet south of the HC wells, and be associated with fractures and pathways associated with the faults.

- ***ADEQ response to Comment #6.16***
  ADEQ is requiring extensive monitoring near the mine blocks. If, based upon an evaluation of groundwater monitoring data, more POC wells are required, primarily in the south, then ADEQ will require Excelsior to install and monitor additional POC wells. However, the addition of additional POC wells is not warranted at this time.

POC wells are the only monitoring beyond the HC wells~~extend along the north and south boundaries, with some buffer as established~~ on the east side of the project. There are just four of them, spaced at over 1200 feet and up to 2000 feet. If a plume does escape the HC wells, the POC wells would not reliably detect it. EPA should require modeling of leaks from the project, without the HC wells operating, to estimate the likely plume that would develop, including dispersion, to determine the needed spacing. EPA should require POC wells spaced according to the update plume modeling.

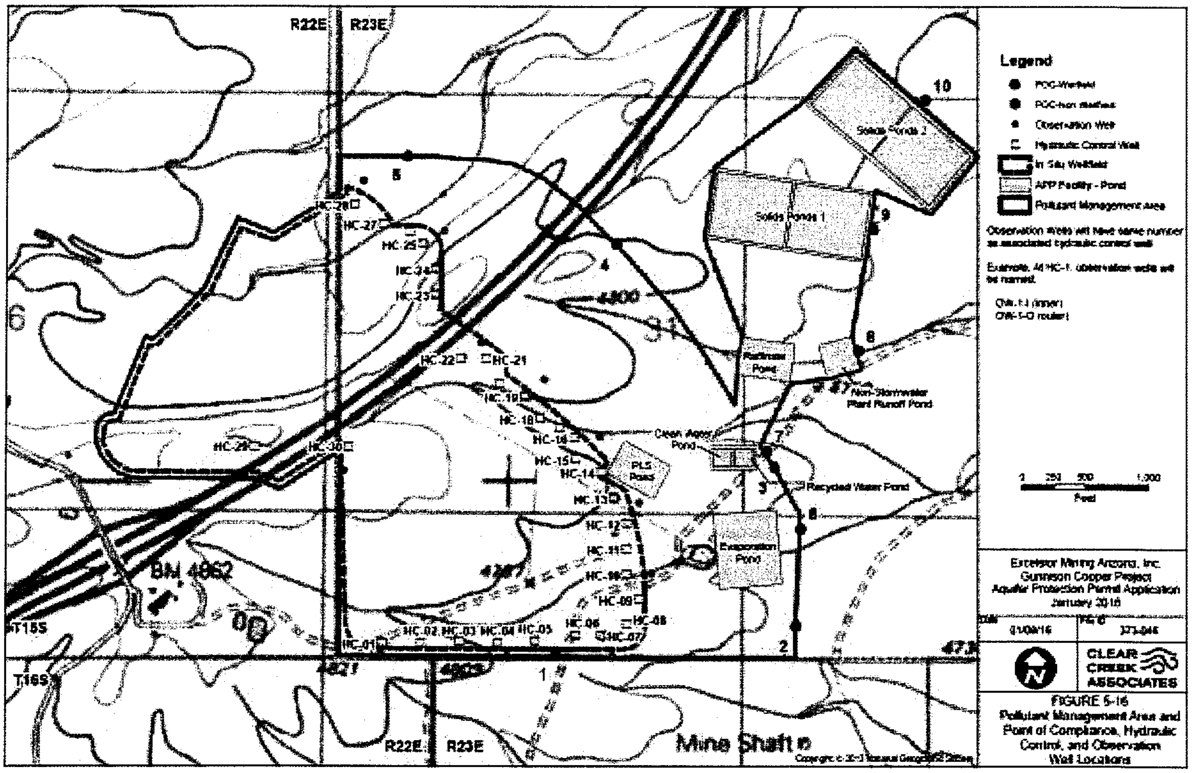
IMW wells appear to be the primary operational water quality control wells. There would be two rings of IMW wells between the operating mine area and the HC and OW wells (Draft permit, Appendix I, p 8). The inner ring is for operator control and results would not be reported. The outer ring would be monitored for SC to detect movement of fluids away from the mine area. If SC increases beyond certain limits, there would be mandatory change in operations to prevent further excursions of fluids from the mining area (Id.). Draft permit, Appendix I (p 9) claims the "general principle" is to locate IMWs along "more conductive fluid pathways". it also claims that "aquifer test results show that all the structures are hydrologically well connected", so as long as an IMW intersects a structure or bedding feature, the IMW should "respond to and detect potential migrations outside the active mining area in that direction" (Id.).

- The premise of locating the IMW wells along a pathway is correct, but the claim is that pump tests show interconnectivity is incorrect, as discussed above. Also, the claim that interconnectivity would allow an IMW to show contaminant excursions would require that the ~~, to assure that~~ contaminants disperse through all of the interconnected pathways. This has not been shown and is highly unlikely because contaminant migration will follow gradients and disperse unequally through a pathway. The permit should require monitoring of pH in addition to SC at the IMWs.

that could provide good early warning of a loss of hydraulic control through pathways~~do not flow in unpredicted directions.~~

There is no point in monitoring pH in an acid consuming host rock because pH will neutralize rapidly away from the active mining area. Geochemical model described in Attachment H-2 to the UIC application indicates that PLS will be neutralized within one day. Monitoring for pH would an unreliable method to detect excursions.

POC and outer OW



~~*Figure 7: Figure 5-16 (CCA 2016) showing the point of compliance*~~ *wells* would be used for water quality monitoring of the perimeter of the project. ~~*, observation wells, and hydraulic control wells.*~~

The Draft permit does not establish concentration limits, but notes they ~~specified for the POC wells~~ are TBD (to be determined) (Draft Permit, Table 2). ~~grossly insufficient, which is unfortunate because the POC wells are the last line of defense for determining that contaminants are escaping the well field.~~ First, many of the parameters would only be monitored with alert limits set for fluoride, nitrate+nitrite, antimony, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, nickel, selenium, thallium, adjusted gross alpha, radium 226+228, benzene, toluene, ethylbenzene, and total

xylenes. The draft permit would ~~only~~ require only monitoring for various other parameters; some monitor-only parameters, including total dissolved solids (TDS), specific conductivity (SC), and pH (Draft Permit, Table 4.1-5B), are the best indicators of a problem with the well field. There is a series of intermediate monitoring wells (IMWs) at which SC would be monitored daily.
~~including total dissolved solids (TDS), specific conductivity (SC), and pH (Draft Permit, Table 4.1-5B), are the best indicators of a problem with the well field.~~

~~The draft permit establishes ambient groundwater monitoring for the POCs that should be completed prior to commencement of mining. It would require a minimum of 8 and maximum of 12 sampling events, with a minimum frequency of weekly and maximum of quarterly (Draft permit, section 2.5.3.1.2). because this could be completed in as little as 8 weeks, the sampling could reflect ambient conditions for only a portion of the year.~~

The method for setting the alert level would be based on the method used by Arizona DEQ (Draft Permit, Appendix I, p 6), using observed ambient conditions, with AL=M+KS with M being mean, S being standard deviation, K being the one-sided normal tolerance interval with a 95% confidence limit is standard. The concentration values would account for dilution if the screens are too large, as described above.

- The alert limits and aquifer quality limits should be set and enforced for each POC, by screened interval, to set limits and commence mitigation based on preferential pathways.

- *ADEQ response to Comment #6.17*
  Please see ADEQ response to Comment #6.14, in relation to how the interconnectivity of the bedrock allows for the permitted method of setting ambient groundwater quality. In addition, in setting ALs and AQLs, if concentrations of constituents are not detected above their respective AWQSs, the AQL will be set to the AWQS, so statistical "dilution" will not take place. In relation to the list of constituents being monitored as not being extensive, ADEQ does not agree. The list is very extensive and protective for the downgradient aquifer. As to the statement that the APP only requires monitoring for ALs, the commenter is incorrect. The constituents listed by the commenter include both ALs and AQLs.

- ~~The permit should require monitoring of pH in addition to SC at the IMWs, OWs, and HCWs; that could provide good early warning of a loss of hydraulic control through pathways.~~

- The concentration limits specified for POC wells should account for dilution. This would account for the fact that standards could be exceeded over a portion of the water column but not all of it. Failing to acknowledge that can lead to downgradient resources being affected if they depend only on a small thickness of the aquifer.

> - *ADEQ response to Comment #6.19*
>   *The accepted groundwater monitoring and sampling methodology listed in Section 2.5.3 of the APP takes into account the concerns listed above.*

The draft permit specifies various actions that will be taken if alert levels are exceeded, but they are in the longer term insufficient. The draft permit must indicate that if exceedances last for more than six months, the facility, or at least the specific section of the well field responsible for the exceedance, must cease operations and commence rinsing. This is because the exceedance is an indicator that the hydraulic control has been lost. Exceedances lasting more than six months indicate that other steps taken have not worked. The only way to protect downgradient aquifers would be to cease operations.

> - *ADEQ response to Comment #6.20*
>   *ADEQ does not agree that the contingency language in the permit is insufficient. Per Section 2.6.2.4.1.1 of the APP, Excelsior is required to conduct the following actions if the SC is exceeded at the HCW and/or OWs:*
>   *a. Continued monitoring*
>   *b. Adjust operations to reverse the trend (pull back solutions)*
>   *c. Adjust pumping in the appropriate HCWs*
>   *d. Install and activate additional interceptor HCWs (if not already installed)*
>
>   *In addition, Sections 2.6.2.4.3.1 and 2.6.2.4.3.2 require cessation of operations in the event of loss of inward hydraulic gradient and net extraction.*

Excelsior proposed the POC wells be monitored for four quarters after rinsing is complete (CCA 2016, p 7-13). [redacted] residual particles to reach the POC wells.

- The UIC permit requires that MCLs have to be met for 5 consecutive years in the wellfield before final closure, therefore the comment is irrelevant. No contamination will exist to migrate offsite.

- *ADEQ response to Comment #6.21*
  Section 2.9.1.2 of the APP indicates that when all Closure Verification Wells (CVW) have met rinse verification standards for five consecutive years, monitoring may stop and all wells (Rinse Verification Wells (RVWs), CVWs, HCWs, Observation Wells and POC Wells) may be plugged and abandoned. This condition is protective, as it requires no exceedances of AWQSs, or ambient conditions if AWQSs are exceeded during post-closure monitoring, within the wellfield and the Observation Wells. This requirement will ensure that there will not be an exceedance in the POC Wells after the end of the post-closure groundwater monitoring period.

- Monitoring beyond the end of rinsing should continue as long as the estimated travel time for particles from the most distant part of the well field to reach the POC line, plus at least 50% for a safety factor.

~~Review of Groundwater Modeling Report - Attachment A-2~~

~~There would be OWs included on the site, as shown in Figure 7. However, the draft permit and the application refer to observation well pairs (Draft Permit, Table 2.5-2), but none of the figures show enough detail to show what a "pair" means. They are intended to show that the hydraulic control wells are maintaining an inward gradient. There are insufficient OWs shown in Draft Permit Table 2.5-2 to show the gradient at each hydraulic control well. The observation wells are insufficient for proving the maintenance of an inward hydraulic gradient, as described in the Draft Permit, section 2.6.2.4.3.~~

~~POC wells are designed for compliance monitoring and would be sampled quarterly with provision for more frequent sampling once exceedances occur. The IMWs, HCWs, and OWs are used for internal flow management and are monitored for SC (and preferably pH, as suggested above) on a daily basis. The HCWs and OWs would also be monitored for groundwater level.~~

- ~~POC monitoring should be conducted monthly during the first year of commercial production, bi-monthly in the second year, quarterly from year three through five, and biannually thereafter. POC wells should be drilled at least one year prior to commercial operation so that baseline data gathering can begin at all of them.~~

- ~~Instead of daily sampling, SC, pH, and water levels should be monitored using automated sensors to save costs of visiting the wells daily and to provide real-time control over operations onsite.~~

~~There are facilities on the mine site, other than the injection/collection wells, that can lead to groundwater contamination, including two solids ponds, a raffinate pond, PLS pond, evaporation pond, and recycled water pond (Figures 6 and 7). The draft permit does not indicate whether these ponds would have liners, although Table 1-1 of the application indicate they would be lined. The draft permit only discusses liner failures.~~

- ~~The draft permit should be amended to specify which ponds require a liner and what kind of liner (thickness) with leak detection required.~~

~~Groundwater Modeling Report -Appendix I~~

Clear Creek Associates modeled the regional hydrogeology using the MODFLOW computer code (CCA 2016, Attachment A-2~~Appendix I~~). MODFLOW is a program that solves the equations of groundwater flow by completing a water balance among model cells. A model cell is a three-dimensional rectangular volume in which various properties of the geology are described. Those properties usually are an average of properties that could vary at scales much smaller than simulated with the cells. The modeler inputs the model domain structure, material properties, and known groundwater flow inputs to the model which solves the equations specifying the water level or pressure over the model domain and the groundwater discharges to various points. The model domain is the aquifer volume being modeled.

Excelsior relied on the numerical groundwater model to show that their project will control the hydraulic gradients and prevent contaminants from escaping to the surrounding aquifer. This section reviews the model and shows that it is not sufficient evidence to show there will be no escape of contaminants.

Model Structure

Solving the equations completes a water balance among model cells that describe parts of the domain. For this site, the cells range from 300 feet to 75 feet square, with the finest discretization in the well field (Figure 9~~8~~), which allows for more detailed calculations. The model domain extends from the Little Dragoon Mountains in the northwest to the Dragoon Mountains in the southeast (Figure 9~~8~~).

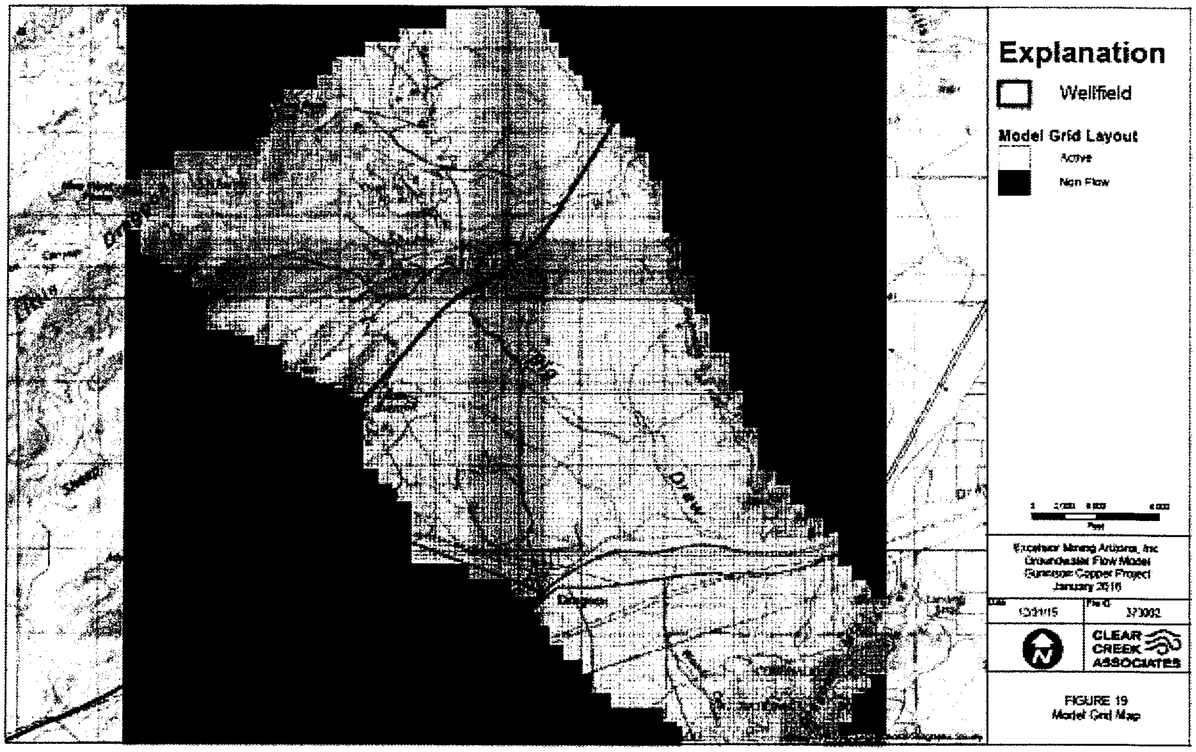


Figure 9~~8~~: Figure 19 from CCA (2016) Attachment A-2~~Appendix I~~ showing the groundwater model grid.

Vertically, the geologic formations are divided into seven layers. Layer 1 varies from 85 to 1648 feet thick, while layers 2 through 5 are 300 feet thick, and layers 6 and 7 are 400 feet thick (Figure 10~~9~~). All layers are bedrock in the west where bedrock outcrops in mountains and layer 1 is basin fill everywhere other than at the outcrops (p 18). Layers 2 through 4 have decreasing amounts of saturated alluvium corresponding with the deep fill east of the project. The lower portion of all layers is horizontal, meaning that formations dip through the layers (Figure 10~~9~~). Layer 1 is unconfined, layers 4 through 7 are confined, and layers 2 and 3 are convertible, meaning the model would treat them as either aquifer type depending on the simulated water level. The layers are much too thick to accurately simulate the flow around the injection/collection wells which would depend on fracture zones.

- Because the wellfield will be operated with injection equal to recovery pumping rates, the model layering is designed only for simulation of hydraulic control well operations and the general movement of water through the ore zone. The layer thicknesses are well suited to meet these objectives. Simulation of individual fractures is not warranted. Large fracture zones with significant width based on interpretation of geologic core are represented using high hydraulic conductivity as interpreted from the fracture intensity observations in the core.

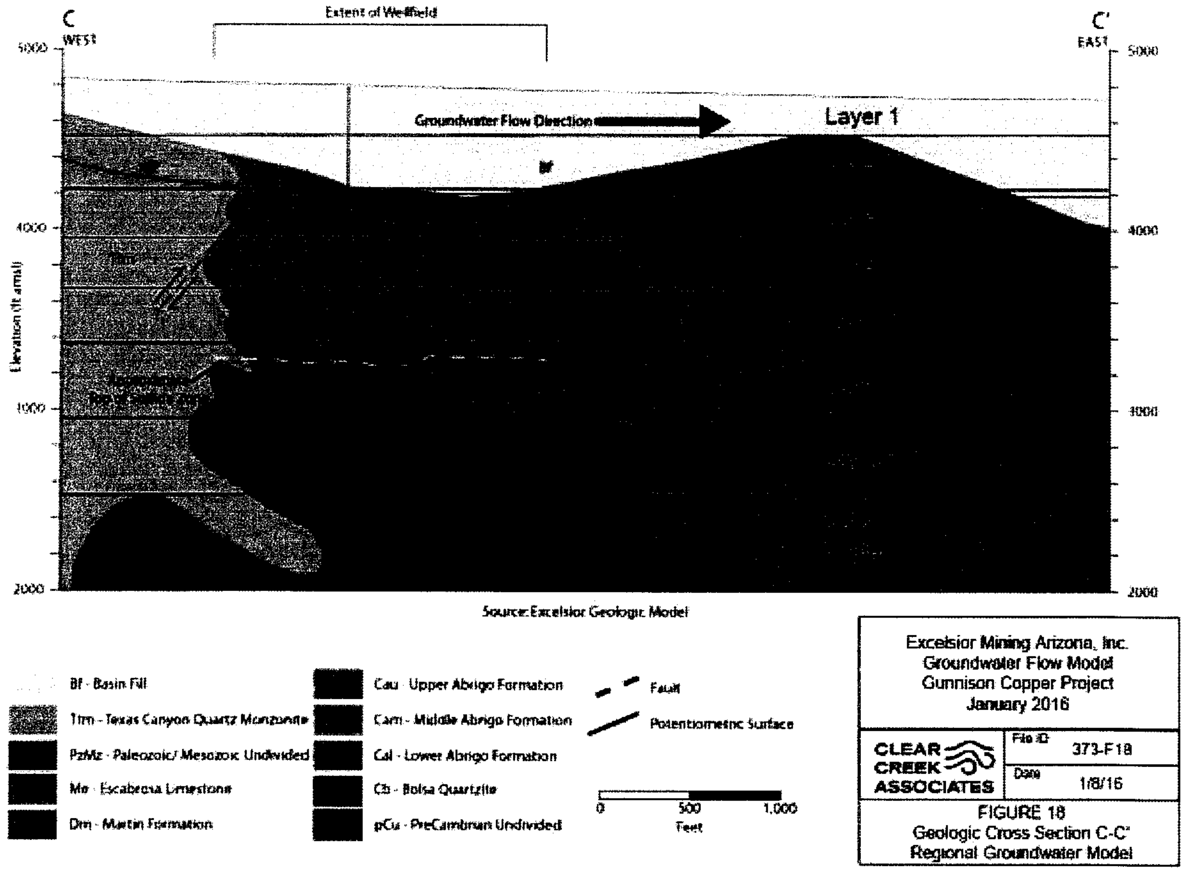


Figure <u>10</u>~~9~~: Figure 18 from CCA (2016) showing the model layers and geologic formations dipping east through them.

The model includes neither horizontal anisotropy or an orientation of grids to align with the fracture orientation, which would facilitate simulation of horizontal anisotropy (Attachment ~~A-Appendix 1-~~p2, p 18). This is a failure to consider the preferential flow potential parallel to the fracture orientation (see the discussion above regarding horizontal anisotropy).

- Horizontal anisotropy is accounted for in the model through the distribution of high permeability zones representing intensely fractured faults. The K distribution zones are based on the detailed geologic model which is itself based on numerous core holes. Figure A shows the locations of the core holes used to develop the geologic model. Faults and fracture zones are well defined using this network of core holes.
- ADEQ found that there was no need to simulate horizontal anisotropy. They state (ADEQ APP Response #6.2): *The groundwater flow model does consider horizontal anisotropy in its design. The major faults systems are presented with higher hydraulic conductivity values essentially creating anisotropy within the model. This method also accounts for any preferential flow paths (major fault systems) that may be present.*
- The model was designed such that three layers represents the ore-zone, with injection recovery activity. The model grid refined area was constructed based on the available geologic model, at the scale of that dataset. Anisotropy is simulated based on high conductivity zones. The grid was aligned with the east-west and north-south oriented fractures. The model could have elected to align with the northeast-southwest set or the northwest-southeast set, but since groundwater flows west to east, regionally, it was aligned with the regional principal flow directions.

Boundary Conditions

The water balance and flow equations require boundary conditions where either the water level, a groundwater flow, or both are specified. There are no flow boundaries on the north, west and south bounds of the model domain which generally coincide with a topographic and expected groundwater divide, as is appropriate. A no flow boundary is one through which groundwater does not flow and generally means that groundwater flow is parallel to the boundary. Recharge is the boundary in this model which provides the flow through the aquifer system. The estimated total recharge was 738.2 af/y for the entire model domain after calibration, which the modelers divided into Walnut Wash and Big Draw areas (CCA 2016, Attachment A-2, Table 4). This is discussed in more detail below.

Attachment A-2

~~calibration, which the modelers divided into Walnut Wash and Big Draw areas (CCA 2016, Appendix I, Table 4). This is discussed in more detail below.~~

~~Appendix I~~ Figure 30 shows constant head boundaries for flow to the east. There is one to the north where Walnut Wash leave the domain and one the south through the gap where Big Draw leaves the domain. Because the boundary on the north is much longer than the boundary on the south, there may be a tendency for flow to go north, although the conceptual flow

model does not justify this. The outflows are with constant head boundaries through layers 2 through 7, with the same head in each layer (p 20). This means the modeling does not impose any vertical gradient at the model boundary. Because the report does not provide water balance data, it is not possible to assess the reasonableness of the constant head boundaries through which groundwater flow leaves the model domain.

- Spatial and vertical water level data are very limited in the area of basin fill east of the Gunnison project. The constant-head boundaries were developed during model calibration and reflect the most current understanding of the groundwater system in that area. As there are no vertical data along the eastern boundary, it would be disingenuous to speculate about the presence of a vertical gradient.
- A water balance for the model domain selected for the Gunnison Project is rather simple. It includes only recharge from precipitation falling on the model domain area and outflow of groundwater through the two gaps in the Gunnison Hills. Other input/output parameters found in other basins are simply absent here including perennial water bodies such as rivers or lakes; diversions of surface water; large pumping wells for municipal, industrial, or agricultural purposes; and irrigation of agricultural lands.
- The key input assumption to the groundwater model is the amount of infiltration to the model domain due to natural precipitation. Clear Creek spent considerable time assessing this input parameter because it can be linked to local rainfall for which there are good historical records. In addition, other researchers from agencies such as the USGS have established what the likely amount of recharge is from precipitation that makes sense for the climatic conditions in this area. Recharge from precipitation is the only source of water to the model domain chosen for this project because all upgradient boundaries are at the edges of the hydrologic basins making up the model domain. If the amount of water entering the model via precipitation can be justified, the amount of water exiting the basin via groundwater is easily estimated. The model was calibrated in steady state as justified by the measurement of steady water levels in numerous wells. The amount of recharge to the model domain is discussed in detail in the UIC application (Section 2.5.2, Table 4, Appendix A-2). 738.2 AF/yr is estimated to enter the model via recharge of precipitation, therefore the same amount is expected to leave the model as groundwater flow through the Walnut Wash and Big Draw gaps.
- The model simulates a simple system: recharge comes in, and underflow goes out. It is presumed to be in a steady-state condition due to the minimal pumping in the basin. Under steady-state conditions, there should not be large vertical gradients, particularly at the boundary. The nature of the boundary cells is unimportant, other than to establish the head values in the model. Fluxes out of the model domain will be divided among the cells and cannot exceed the total inflows from recharge. The length of the boundary merely spreads the outflows along a line, but it does not change them.

Modeled Material Properties

The model includes material properties, which are generally set by calibration guided by prior knowledge of the formation properties. The prior information was the pump tests and transmissivity estimates discussed above. This section discusses the modeled material properties. The modelers establish hydrologic parameters using the parameter zone method, meaning that a given geologic formation was assigned a series of parameter values. Excelsior assigned the parameter blocks and values based on their combined geologic/fracture intensity model, as critiqued below.

The final parameter values were set by calibration, described below, and the Initial values used for calibration were based on correlation between fracture intensity and hydraulic conductivity. Excelsior estimated fracture-intensity for 100 by 50 by 25 feet thick blocks within and near the ore body. The geologic model was incorporated into finite difference model cells. Outside the ore body, material properties were based on mapped geologic units. Each modeled material was divided into five property zones to specify K for the formations in the model, based on the conductivity/fracture intensity relationship (CCA 2016, Attachment A-2~~Appendix I~~, p 19). Outside the ore body, a sixth property zone was used to simulate properties that were not as fractured as within the ore body. The fracture intensity was assumed lower away from the ore body, which resulted in a lower simulated conductivity away from the ore body. This has the effect of containing the simulated effects of mining to the project site.

The fracture intensity is much higher in the areas with significant faults, as shown on Figure 11~~10~~. Faults trends just west of north through the domain south of the project site and curve to a more northwest trend near the site. The yellows and reds on the fracture intensity model is the ~~area of higher fracture intensity. Fracture intensity is much lower west and east of the project~~

area of higher fracture intensity. Fracture intensity is much lower west and east of the project area.~~area.~~ A model fit shows that conductivity ranges from 1 to about 10 ft/d for the higher fracture intensity (Attachment A-2~~Appendix I~~, Figure 16).

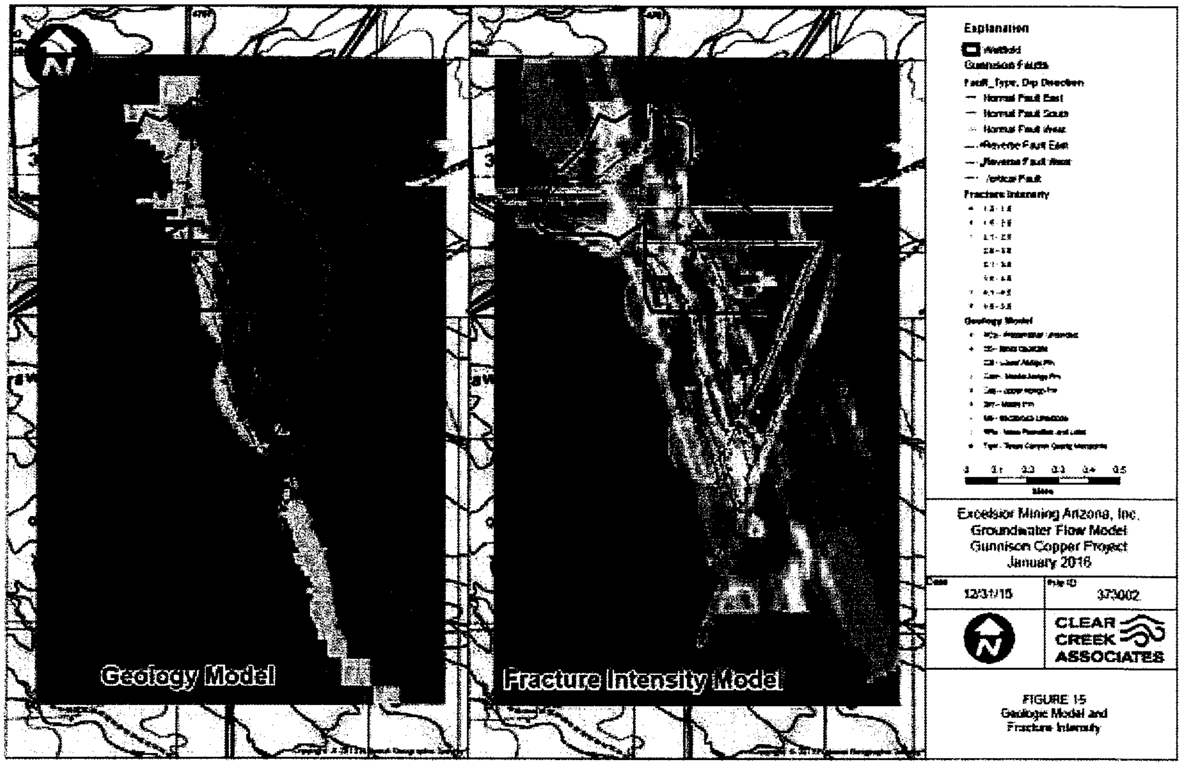


Figure 11~~10~~: Figure 15 from CCA (2016) Attachment A-2~~Appendix I~~ showing the geologic and fracture intensity model.

Attachment A-2~~Appendix I~~, Table 9 summarizes the hydraulic conductivity values by formation type and fracture density. Fracture density is rated from 1 to 5 with increasing density corresponding to increasing values. A 0 was used for formations away from the areas with fracture intensity measurements. [redacted]

[redacted]

- The following figure illustrates the level of detail included in the distribution of fracture intensity zones used to build the groundwater model.

- ADEQ provided the following additional response regarding FI values assigned as "0" (ADEQ Comment #6.25):

In Table 9, Appendix I, fracture intensity values of zero (0) were set in the model for regional data outside the wellfield. This was for coding purposes only as fracture intensity logged by Excelsior only ranged from 1 to 5. Therefore, the value zero does not follow the typical fracture intensity/conductivity relationship. Texas Canyon, Undifferentiated Paleozoic Rocks and Naco Formation were used for regional calibration and the hydraulic conductivity zones representing them were adjusted during calibration of the steady state model. Even so, these formations generally show the appropriate relationships. As stated in ADEQ response to Comment #5.1, Excelsior shall reevaluate the groundwater flow model after the first year of operation in Stage 1.

2. With the exception of basin fill, there is no simulated difference among Kx, Ky, and Kz. This means the model would treat conductivity in all directions for all bedrock formations equally. The very nature of fractures is they tend to be more prominent in a primary direction, so this table violates that precept. Due to bedding in sedimentary rock (most of the formations), there is also tendency for flow along the dip rather than perpendicular to it. Both would cause $Kx \neq Ky \neq Kz$.

- ADEQ (Response Comment #6.26):

  ADEQ agrees that Table 9 does not include differences in Kx, Ky, and Kz. However, the model does take directional differences in permeability into account by assigning hydraulic conductivity horizontally and vertically directly from the mine geologic model which is based upon detailed core logging. In this way, the model accounts for differences in horizontal and vertical flow in a more realistic way than by introducing anisotropy through cell-by-cell variation of Kx, Ky, and Kz.

- Figure A presents a figure illustrating the density of core holes used to interpret the geology and from which the interpretation of fracture intensity was derived. The density of core hole data and therefore observed FI values translated into the model as a detailed interpretation of the hydrogeologic distribution of K making the model a realistic representation of the overall fracture system.

3. The conductivity values are commonly the same depending on fracture intensity rather than formation type. For example, for fracture intensity 4 and 5, K = 10 and 65 ft/d, respectively. There are other examples. This suggests there have been too few aquifer tests to justify discretizing among so many formation types. It also means there are no differences among geologic formation types.

- In the area of the ore body, the permeability associated with fracturing is independent of formation; therefore, the K value associated with a particular FI value dominates the interpretation of what K value to assign. The breakdown of FI values by formation was done purely to allow visual distinctions in the model between different formations. Outside of the ore zone, K values for different rock types were developed through calibration.
- Additionally, ADEQ included Comment Response #6.27 as follows:

ADEQ does not agree that there has been too few aquifer tests. The hydraulic conductivity for the sedimentary units are the same for Fracture Intensities 4 and 5, except for the hydraulic conductivity for Fracture Intensity 4 in the Naco Formation. In the geological model, fracture intensity is not assigned based on the formation type, but instead is based on what was observed in the drill core, independent of formation. The separation of formations in developing the hydraulic conductivity distribution of the model was done to allow visual distinction of the different formation in the model and to allow refinement of calibration locally, if needed. An example of local refinement during calibration is the fracture intensity 4 unit provided for the Naco Formation.

4. There are six zones for each geologic formation. The text claims the formation outside of the ore body is not mapped with respect to fracture intensity, represented by zone 0 for each formation on the table. They claim that "fracture intensity appears to be strongest in the area of the ore body" (Attachment A-2~~Appendix I~~, p 19), therefore the conductivity outside the ore body is usually lesser than within the ore body. However, they did not sample outside the ore body, so there is no data or evidence to support this claim. Table 9 does not confirm this statement because there are examples of the ~~intensity 0~~

Intensity 0 (outside the ore body), having a higher conductivity than within. If the model has higher K within the ore body, it would simulate less head drop and easier flow through the ore body than around it.

- The regional geologic structure is related to the placement of the Texas Canyon Quartz Monzonite (Tqm), with faulting and fracturing related to the intrusion and the copper mineralizing event. It is thus logical to conclude that the sedimentary rocks are less fractured away from the Tqm and the mineralized ore body. The oxidation of the copper mineralization has also greatly increased the permeability of the fracture system. Fractures without oxidized copper mineralization are considerably less permeable. Therefore, rocks that are un-mineralized, un-oxidized and away from the TQM and copper orebody are by nature significantly less fractured and permeable.
- DEQ included Response Comment #6.28 as follows:

  The average fracture intensity from geological logging in and adjacent to the ore body is just over a value of 2. Although sporadic drill core from more distal locations shows significantly lower fracture intensity this was not incorporated into the model. Instead, to be more conservative, the regional rocks were coded to a fracture intensity of zero (0) with a hydraulic conductivity approximately equal to the average for the ore body and immediate surroundings. This will be evaluated pursuant to ADEQ response to Comment #5.1.

5. <u>Attachment A-2</u>~~Appendix I~~, Table 11 purportedly includes calibrated K values, but shows values as high as 65 ft/d, whereas the figures showing calibrated K zones with values (App I, Figures 21-27) do not show any values greater than 10 ft/d. This is a substantial error in the presentation of the model parameters.

- Values of 65 ft/d were assigned to fracture intensity values of 5, based on the curve fitting. Since no model cells were assigned to these hydraulic conductivity zones because no model cell FI had an average of 5, the actual K value of FI=5 is not relevant to the model results.
- ADEQ included Response Comment #6.29 as follows:

  ADEQ does not agree with the statement. Table 11 shows the groundwater model calibration results. It only includes observed and computed groundwater elevations. It does not include hydraulic conductivities.

The conductivity values for each material zone (App I, Figures 21-27) are the result of the steady state calibration, details of which are described below. Values for layer 1 show the meeting of the bedrock outcrops on the west with the basin fill on the east, with low values, less than 0.01 ft/d matching with higher values, 1 to 10 ft/d for the fill (Figure <u>11).</u> ~~10).~~ The low K for bedrock under the outcrop extends down through all seven layers (App I, Figures 21-27). This low K area causes the steep groundwater contours west of the well field. The high values for basin fill, 1 to 10 ft/d, shown in red running north-south through the valley east of the project, extend to layer 5 to represent the full thickness of the fill (Attachment A-2~~Appendix I~~, Figures 21-25), primarily causes the flat groundwater contours seen in this area. At depth, bedrock K is low, with K less than 0.01 ft across the southeast portion. At shallower layers, higher K from 0.5 to 1.0 ft/d provides a conduit for flow to reach the boundary outlet from the domain in the southeast.

~~1.0 ft/d provides a conduit for flow to reach the boundary outlet from the domain in the southeast.~~

Because of the fracture intensity modeling, the model has very detailed parameter zone models within the ore bodies, as can be seen from detailed observation of the ore body on the parameter zone maps for each model layer (App I, Figures 21 -27). Most of the well field area has K equal to 0.5 to 1.0 ft/d, with some intermittent higher and lower cells that resulted from the detailed fracture intensity modeling. The west half of the ore body has the most detailed parameter zones, as may be seen in the magnified portion of App I Figure 22 shown in Figure 12 ~~11~~

for layer 2. The complicated fracture intensity model may represent the fractures associated with faulting, as shown in Figure 1 1~~12~~.

Figure 12~~11~~: Magnified portion of Attachment A-2~~Appendix I~~, Figure 22 showing the details of the parameter zones on the west side of the ore body, and to its south.

Note: Figure 12 shows the distribution of hydraulic conductivity in a shallow layer which therefore includes significant basin fill to the east of the mining area.

Recharge is a specified flux boundary to the model, meaning the modeler sets a constant value that is forced to enter the model at a given point. It is the boundary that inputs water to the model. Recharge is distributed around the model domain jointly with the setting of hydraulic conductivity, because the conductivity controls groundwater flow through the model domain and sets the observed water levels. The modelers assumed an average 12.5 inches of precipitation with 3% becoming recharge, "based on other similar modeling studies" (Attachment A-2~~Appendix I~~, p 12). [redacted] or provide any support to the use of 3% in this area. The modelers adjusted the recharge percentage to ~~the use of 3% in this area. The modelers adjusted the recharge percentage to~~ 2.8% of annual precipitation, presumably due to an inability to force the recharge into the model without using unreasonably high conductivity values. Conductivity controls the ease with which recharge enters the model domain, and during a steady state model simulation, the model would establish the groundwater level at that necessary to create the gradient necessary to force the water into the domain. If the water level is unreasonably high, the modeler has the choice of changing the amount of water being forced into the domain or changing the conductivity to ease the entry of the flow.

- Groundwater recharge used in the modeling study is reasonable. Calibration was adjusted by changing hydraulic conductivity values in zones where there was little or no field measurements. To the degree possible, K values in the area of the mining operations were assigned values consistent with the relationship between K and FI.
- Studies that support the assertion that recharge should be about 3 percent of precipitation are described as follows:
  - A study by the USGS (Robson and Banta, 1995) suggested that on average, 5% of precipitation is recharged to alluvial basins in the Arizona, Colorado, New Mexico, and Utah areas. More recently, Blasch, et al (USGS, 2006) estimated that 1.3 to 4.4 % of precipitation is recharged to the upper and middle Verde River Watersheds. The Blasch et al report was used as the basis for developing input assumptions for the Northern Arizona Regional Groundwater Flow Model (Pool, et al, 2010).
    - Blasch, K.W., Hoffmann, J.P., Graser, L.F., Bryson, J.R., and Flint, A.L., 2006, Hydrogeology of the upper and middle Verde River watersheds, central Arizona: U.S. Geological Survey Scientific Investigations Report 2005–5198, 101 p., 3 pls.
    - Pool, D.R., Blasch, K.W., Callegary, J.B., Leake, S.A., and Graser, L.F., 2010, Regional Groundwater-Flow Model of the Redwall-Muav, Coconino, and Alluvial Basin Aquifer Systems of Northern and Central Arizona; Scientific Investigations Report 2010-5180, v. 1.1; 101p.
    - Robson, S.G. and Banta, E.R., 1995. Ground Water Atlas of the United States: Arizona, Colorado, New Mexico, Utah, HA 730-C – Basin and Range Aquifers.

Higher flow rates require higher conductivity values for the [illegible] to equal the observed values. Model calibration would establish the conductivity along the flow paths, all else being equal, to be higher to allow a larger amount of water to flow through. If the recharge amount is either too high or too concentrated in one area, the conductivity would therefore also be artificially too high.~~If the recharge amount is either too high or too concentrated in one area, the conductivity would therefore also be artificially too high.~~

- The calibrated conductivity values fall within the range of values measured in site-specific aquifer tests. They are not "artificially too high" as the reviewer suggests.
- If they were "artificially too high", that would mean our model is more conservative because it still shows control and containment and if the conductivity was in reality lower, then control will in reality be easier than we have engineered for.

As part of calibration, the modelers distributed the total recharge around the model domain (Figure 13~~12~~). The noncolored area on Figure 13~~12~~, which is most of the domain away from the mountains and washes, represents recharge less than 0.012 in/y.

The concentrated recharge may significantly bias the model results. The large zone in orange west of the project site in the Little Dragoon Mountains, is recharge from 1.2 to 4.4 in/y (Figure 13~~12~~). Recharge would enter the groundwater in this mountain block only if the geology is highly fractured at the surface, otherwise the area should mostly generate runoff. Much of those mountains have the second highest conductivity values (Figure 14~~13~~), possibly due to the calibration.

- The model does not simulate the physical mechanism for recharge, it assumes that the highest recharge occurs in the upland areas of the model. This is normal modeling practice, since evapotranspiration tends to limit deep percolation in low lying areas. The higher areas receive greater precipitation and have more snowfall. This occurs in the winter when evapotranspiration is lower. This practice is standard for regional models, reflecting the location where recharge occurs.
- Higher recharge is applied in high elevation areas to reflect the fact that more precipitation falls at high elevations due to the well documented orographic effects of topography. Higher recharge is expected in the mountains and is justified by the match between model simulated water levels and measured water levels near mountain areas. Reasonable conductivity values for the observed bedrock were used in the model.

Walnut Wash is a substantial drainage which flows east from these mountains, which indicates there is substantial runoff from the mountains. The model simulates from 0.55 to 6.6 in/y near Walnut Wash west of and within and north of the north quarter of the wellfield. The area is almost 2000 feet wide and over 6000 feet long. The recharge rate into the model domain through the Walnut Wash area is very high, the product of the rate and area shown in red. Most other areas that represent washes are simulated with recharge from 0.12 to 0.5 in/y (green).

- As any visitor to the site can attest, Walnut Wash is a substantial drainage with a wide channel and alluvial fill consistent with high flow runoff. A higher rate of recharge along this wash is justified from observation of the wash geometry, the flattening of the channel in the area of higher recharge, and from water level data at the site.

Only the smallest recharge rate is used for recharge in the Dragoon Mountains in the southeast. Even if the geology is not conducive to distributed recharge, there should be runoff that leads to mountain-front recharge.

- The Dragoon Mountains and the runoff from them play no role in calibration of the model because Big Draw lies between the Dragoon Mountains and the project site.

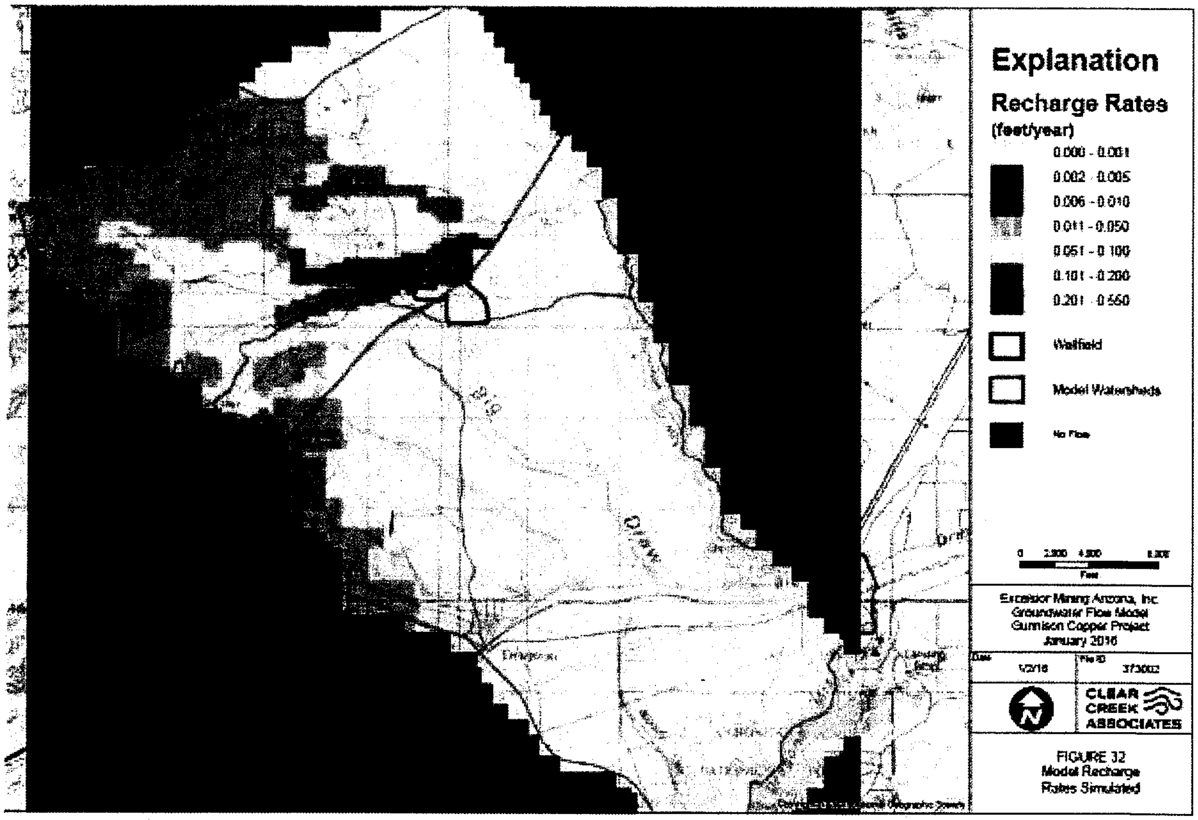


Figure <u>13</u>~~12~~: Figure 32 from CCA (2016) <u>Attachment A-2</u>~~Appendix I~~ showing the calibrated steady state recharge rates around the model domain.

As a result, the calibrated conductivity near the wellfield could be artificially too high. This would cause simulated flow through the area, both regional flow and injected flow to be channeled through large preferential flow areas which would prevent it from flowing away from the well field. Essentially this recharge distribution could channel flow away from Dragoon and other areas, thereby causing the model to not estimate impacts to groundwater users near Dragoon.

- The calibrated conductivity values fall within the range of values measured in site-specific aquifer tests. They are not "artificially too high" as the reviewer suggests.
- If they were "artificially too high", that would mean our model is more conservative because it still shows control and containment and if the conductivity was in reality lower, then control will in reality be easier than we have engineered for.

The recharge distribution used by the modelers forces most of the recharge for the entire domain into the ground in the mountains just west of the project site or along the wash just west and north of the project site. This recharge distribution would cause much higher flows to emanate from that area to the outflow points. Some of the area under the wash has some of the lowest conductivity values, which may be due to the high groundwater elevations west of the site. It also may cause some of the recharge to flow initially to the north where the conductivity is lower.

- Higher recharge in the mountains and along major washes is sensible and is commonly incorporated in groundwater models. There was certainly no attempt to direct flow to the north into areas of lower conductivity as the reviewer implies. The hydrogeology of this area is relatively simple. The distribution of conductivity values at the project site is based on the detailed geologic model developed by the mine geologist. Recharge was applied in a sensible way and the calibration is excellent.
- The mining operation will employ balanced injection and recovery with hydraulic containment maintained around the wellfield through additional pumping of hydraulic control wells. The regional gradient or flow direction is of little consequence given the control that Excelsior will maintain during operations.

The low K in model layer 1 west of the well field (Figure 14~~13~~) coincides with the high recharge in the Walnut Wash (Figure 13). ~~12).~~ This causes the higher groundwater ridge and steep slopes seen in the modeled steady state contours (Figure 15~~14~~). Much of the remainder of the high recharge zones west of the project coincides with higher conductivity material in layer 1.

- Basin fill material has much higher conductivity then bedrock. This has been well documented throughout the state of Arizona. Obviously, Walnut Wash extends over bedrock at the base of the Little Dragoon Mountains to higher K basin fill to the east. Although there is a general paucity of data in the basin fill just east of the project site, it is certainly reasonable to assume the hydraulic gradient flattens where the groundwater table encounters basin fill.

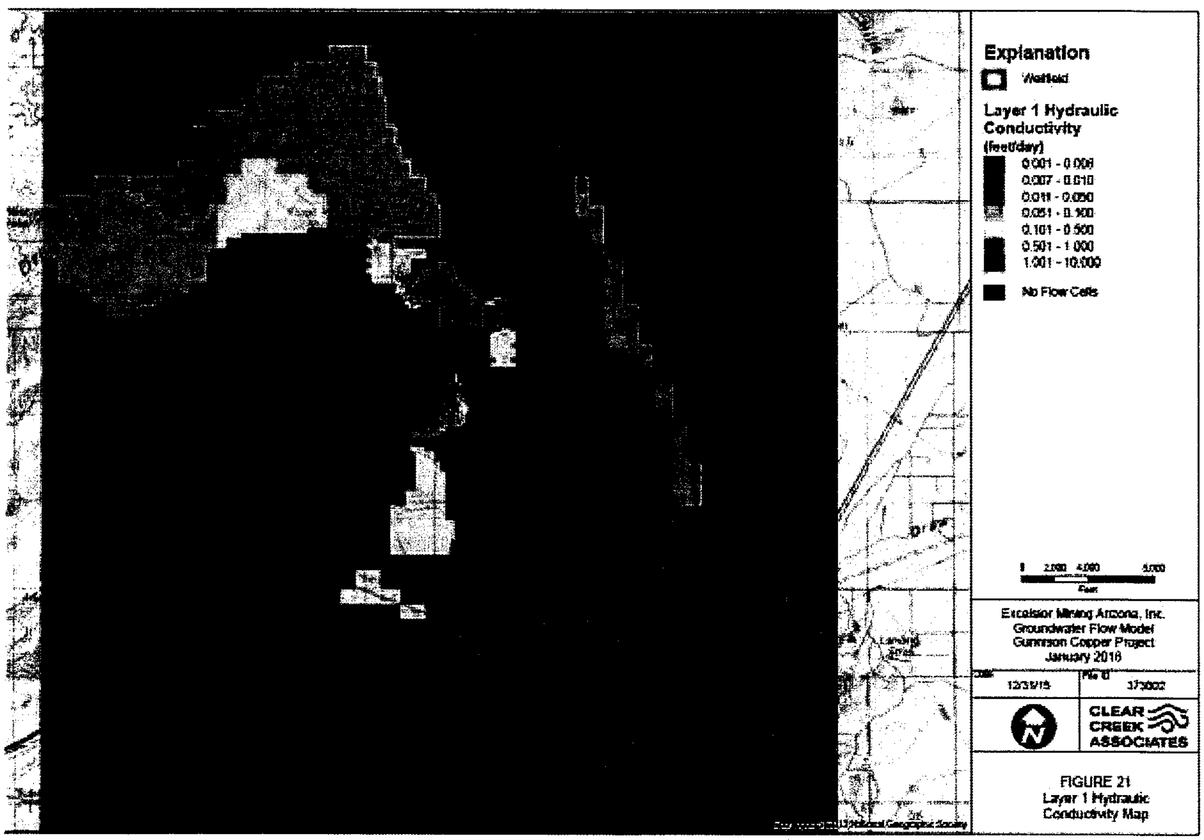


Figure 14~~13~~: Figure 21 from CCA (2016) Attachment A-2~~Appendix I~~ showing conductivity in model layer 1, the uppermost layer in the model.

Vertical K equals horizontal K for all bedrock, so there is no resistance to deep groundwater flow. There is no discussion of vertical circulation as part of the conceptual model, meaning the modelers had no expected natural vertical circulation of groundwater flow. It is likely that the numerical modeling allows an unrealistic amount of water to flow at depth through the domain because of vertical K equaling horizontal K, especially at depths below layer 1. ~~Attachment A-2~~Appendix I does not provide water balance data, either for the entire model or for individual layers, as is customary for the presentation of groundwater model results (Anderson and Woessner 1992). This limits the ability of the reviewer to assess how realistic is the simulated groundwater flow.

- The reviewer should have noted that, in general, modeled permeability decreases with depth which would have the effect of limiting deep groundwater flow. This is readily apparent in the area of basin fill to the east of the site where lower model layers (layers 4-7) have permeabilities consistent with bedrock overlain with higher permeability basin fill.
- As noted previously, the water balance for this site is very simple – groundwater recharge in, groundwater underflow out. Clear Creek provided a detailed summary of the recharge value (UIC application, Section 2.5.2, Table 4, Appendix A-2), therefore the water balance should be obvious.

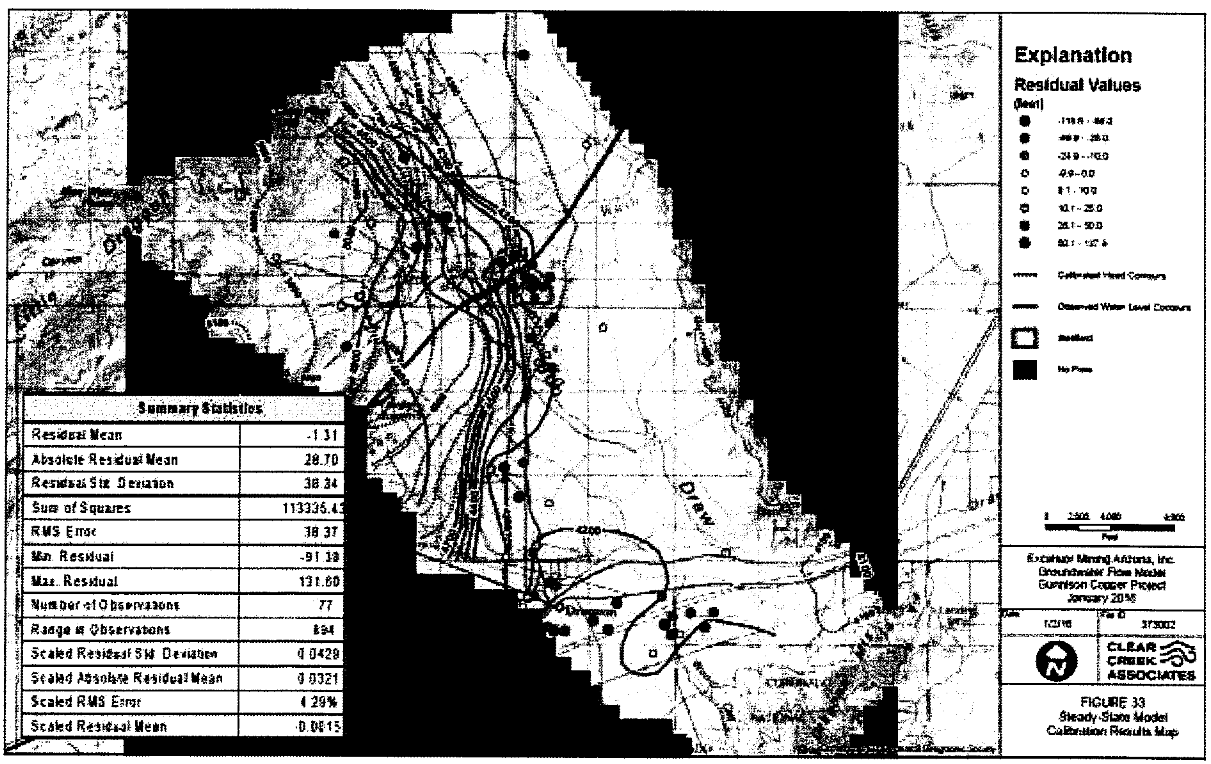


Figure 15~~14~~: Figure 33 from Attachment A-2~~Appendix I~~ showing groundwater elevation contours, residuals at observation wells, and residual statistics.

Storage properties of the material control how much water is released for a unit change in pressure or head. It effectively controls how fast the aquifers release groundwater to pumping. Specific storage was set equal to 0.00001/ft, which ignores the vast variability in values found during the pump tests.

- Storage values were calibrated as part of the transient calibration to the aquifer test at NSH-15. The value derived is consistent with the hydrogeology expected in this geologic setting. Storage is typically not a sensitive parameter.

Faults and fractures play a large role controlling the flow through the model (CCA (2016), Attachment A-2~~Appendix I~~, p 15). The model uses a horizontal flow barrier (HFB) through the middle of the wellfield area to simulate a large head difference observed in the wells (Figure 16). ~~15).~~ The head is variable throughout the area, and there is a lot of variability even within blocks as defined by the faults or HFB. For example, the difference between NSD-028 (4437) and NSM-013 and NSD ~~the faults or HFB. For example, the difference between NSD-028 (4437) and NSM-013 and NSD~~ 027 (4391 and 4376) suggest significant vertical gradients within the block, which suggests the model uses an HFB in appropriate areas. A NW to SE HFB would seem more reasonable to separate NSD-026 (4423), NSH-007 (4427), NSH-008 (4425), and NSD-032 (4437) from NSH-010 (4189), NSH-031 (4198), NSH-032 (4190), NSD-037 (4296); NSH-012 is labeled ~~4747 but its color code suggests it should be 4147. The distance between these groups is generally around 1000 feet.~~ 4747 but its color code suggests it should be 4147. The distance between these groups is generally around 1000 feet.

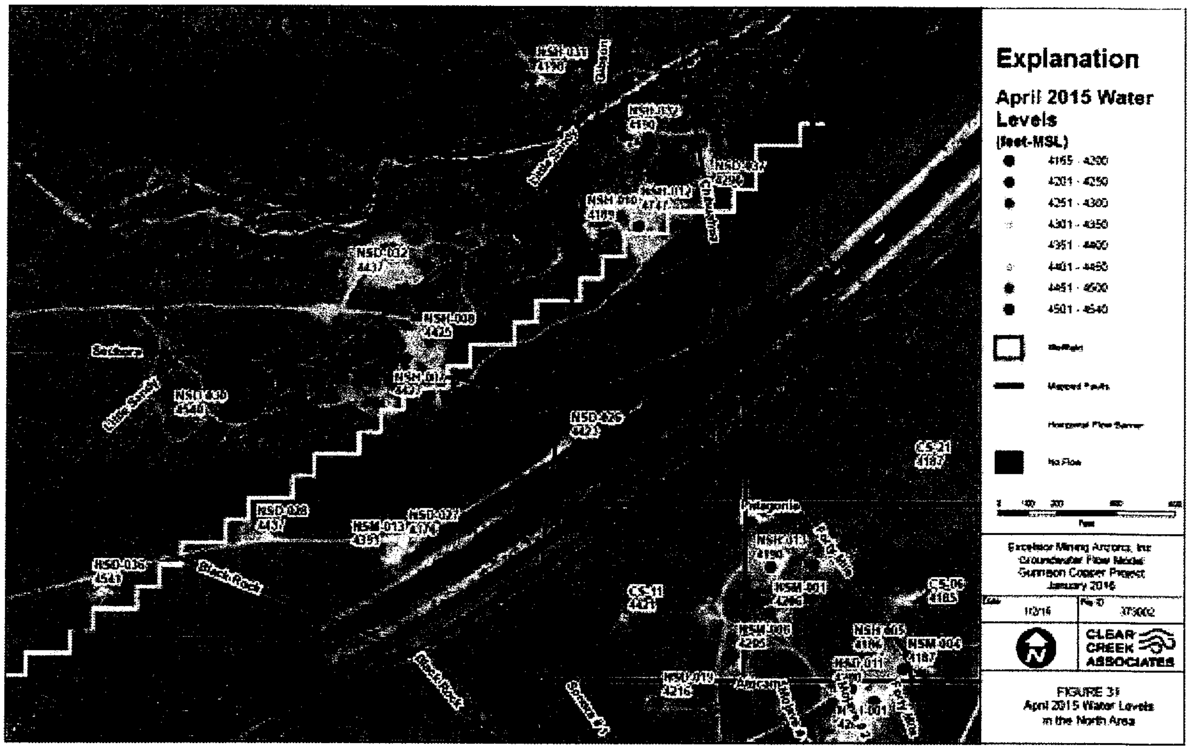


Figure 16~~15~~: Figure 31 from CCA (206) Attachment A-2~~Appendix I~~ showing the horizontal flow barrier and April 2015 water levels near the barrier.

Model Calibration

Calibration is the process of matching simulated and observed head levels by adjusting the material properties to adjust the simulated heads. Calibration also involves matching simulated and observed groundwater flow rates, if there are observed rates available. Steady state calibration occurs assuming the system is at steady state. Because there is little stress in the aquifers near the proposed project, the system currently is close to being in steady state so matching average water levels would be considered steady state calibration.

The description of matching simulated with observed heads (Attachment A-2~~Appendix I~~, p 21) suggests the simulated heads were the water table values from the simulation. This means it is the water level in the uppermost active layers. Model layers for which the bottom of the layer is above the water table are inactive. Because the model allowed layers 2 and 3 to be convertible with respect to being simulated as confined or unconfined, the uppermost aquifer could not be confined because once pressure in one layer goes above the top of the layer, the layer above becomes an unconfined layer. [redacted] other words, the model simulates saturated conditions above a confining layer, which is inappropriate. In areas where the flow is known to be confined, the layer with the flow should be set as confined so the head in the layer may be higher than the top of the layer without flow entering the layer above.

- There is little field data that suggests the presence of a shallow confined aquifer. Given the intensity and pervasiveness of fracturing, it is unlikely that there are any shallow areas that are confined. At depth, semi-confined to confined conditions exist based on interpretation of aquifer tests, but there is no evidence for shallow confined conditions.
- As the reviewer is surely aware, the model was calibrated in steady state mode. As such, values of storage that differentiate confined from unconfined aquifers are ignored in the steady state flow equations. The water table versus pressure head distinction that the reviewer purports is meaningless.

Figure 15~~14~~ shows simulated and observed groundwater contours and residuals resulting from the final calibration. A residual is the difference between simulated and observed values. The simulated heads have a much more consistent gradient and resemble a surface much more than the observed heads. This probably reflects how the model layers represent average values over several fracture zones whereas the observation wells are monitoring different fracture zones. Simulated contour 4200 ft lies a couple thousand feet east of the observed 4200 ft contour which means the simulation results in a potentiometric surface above the observed.

The residuals through the wellfield area transition from high positive values, 50.1 to 137.9 with red circles to high negative values, -115.5 to -50.0 with blue circles over a short distance. The simulated potentiometric surface resembles an eastward dipping plane through a water table that is both far above and far below the plane. This could be the result of a flow barrier that causes the actual water levels to drop but is not included in the model or trying to match observed water levels from aquifers that are not connected. The rapid change in residuals across the site indicate the conceptual model for the area is inaccurate. It could assume connectivity among formations that does not exist, not considering horizontal anisotropy which would cause flow to trend in a certain direction and drop faster in other directions, or assuming more recharge which causes conductivity values that are generally too high. If the fractures trend NW-SE as noted above, simulated east to west flow would be at an angle to the preferred direction based on fractures.

- The distribution of simulated heads that are too high versus simulated heads that are too low as compared to measured water levels in the Gunnison model shows no particular spatial bias, indicating the match is reasonable. The conceptual model is valid.
- Resistance to west to east flow across the project site is evident in the drop in water levels from west to east. The conceptual model indicates that preferred flow will be parallel to the NW-SE faults with less flow perpendicular to these faults. This is common in faulted rock where high flow velocities parallel the fault, but the same fault can act as a barrier to flow in the perpendicular direction.

There is little data for transient calibration, which would attempt to match observed water level changes due to a stress applied to the aquifer by changing storage coefficients. The modelers calibrated to data for a pump test at NSH-015, which included a series of four short-term pumping rates followed by a several-day period of constant pumping at 85 gpm. Drawdown at NSH-019 had been predicted to be 4.89 feet but the model simulated just 0.01 feet (Figure 17~~16~~). This is due to the fracture-dominated flow system and that drawdown depends on the observation well being developed in the same fracture system as the pumping well.

These results demonstrate future problems that will occur with the system. Injection of leachate into a fracture zone that does not have a collection well or a control well will allow flow to exit the system. Figure 17~~16~~ shows however that there is likely an inappropriate model flow barrier between NSH-015 and NSH-019 since the observed drawdown, as noted 4.89 feet, occurs about 500 feet east of the simulated 1-ft drawdown contour. The simulated material properties may not connect high K values to create an actual zone. The model cells are much larger than any fracture zone and the fracture intensity would depend on the observed fractures within the cell.

- The model is a simplification of a complex system. No attempt has been made to simulate individual fractures, nor is this necessary for the purpose and objective of this model. Given that 5 of the 6 observation wells matched closely the pumping test results, the transient calibration to this pumping test was considered adequate.

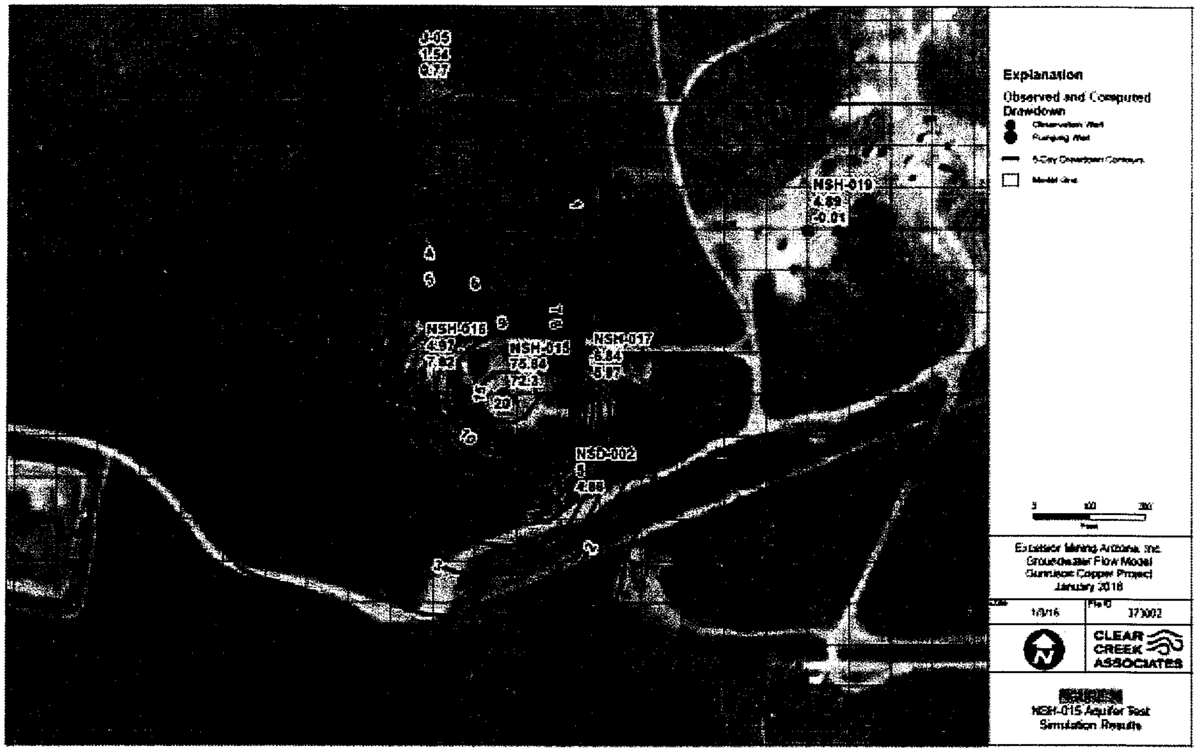


Figure 17~~16~~: Figure 36 from Attachment A-2~~Appendix I~~ showing the drawdown from the pump test at well NSH-015.

As critiqued above, the calibration involved adjusting recharge as well as material properties. This would result in a nonunique model, meaning there are an infinite number of combinations of material properties and recharge that could result in the same simulated head values (the only observed values being matched for calibration). This may be seen from Darcy's Law, which relates flow rate to conductivity and gradient. For a given gradient (defined by the head values), K would vary as flow rate (flux) varies. If flux changes, K changes as well. If the K value is known in advance, the flux can be determined using Darcy's Law. If both K and Q can be adjusted, there are an infinite number of solutions to yield a measured gradient. [redacted]

- All models require adjustment of more than one parameter for calibration. As explained previously, the water balance for this basin is quite simple – recharge in from precipitation, groundwater underflow out. Because the groundwater system is in steady state, there are really only two things the modeler can adjust to achieve calibration: recharge and hydraulic conductivity. In many other models, there are far more parameters that require adjustment for calibration such as irrigation, stream flow, evapotranspiration, pumping rates, diversions, etc.
- As stated previously, recharge is linked to precipitation which is well known. The idea that there are no estimates of recharge is flatly untrue.

The problems with the model being nonunique are that the parameters values may be grossly wrong. This could affect the predicted results of the project simulations and lead to inappropriate assumptions about the operations of the model, especially on a regional basis. By this, I mean that even during operations, Excelsior will adjust injection and collection rates to meet the needs within the well field; elsewhere, the model predictions could be very inaccurate due to inaccurate parameters.

- Absolutely untrue – see response, above.

Model Recommendations

The previous sections provided comments on numerous aspects of the model, but there are two overriding recommendations which would improve the model and improve most of these comments.

- The model should be improved with a better conceptual flow model, that better accounts for the fracture system near the well field due to the faults. It should better simulate horizontal anisotropy as caused by the fracturing. It should have more layers to better simulate the steps in the observed water table.

- The model was constructed using the detailed geologic model to associate fracture intensity with the hydraulic conductivity of the rock. Essentially, the model relied on the numerous core holes drilled for ore body definition to develop the hydrogeologic conceptual model. Figure A shows the core holes used in this process and indicates a considerable understanding of the geology and therefore the hydrogeology. Horizontal anisotropy is accounted for in the model through the distribution of hydraulic conductivity.
- ADEQ included the following response Comment #6.30 to the APP comments:

  ADEQ will require Excelsior to update the conceptual model, as appropriate, along with the groundwater flow model each time the groundwater flow model is reevaluated per ADEQ response to Comment #5.1.

- In 2015, Joanna Moreno, a Professional Hydrologist – Groundwater with the consulting firm Golder and the author of the book "A Practical Guide to Groundwater and Solute Transport Modeling" (Spitz and Moreno, 1996), reviewed the Excelsior Gunnison Project groundwater model. Her review indicated that
  1) the Gunnison groundwater model developed by Clear Creek Associates conforms to industry standards for groundwater models designed for permitting analyses
  2) was successfully calibrated so that model-simulated groundwater levels matched observed groundwater levels, and
  3) that hydraulic control as simulated by the model is successful in containing mining solutions within the mining wellfield over the life of the mining operation.

- The conceptual model should also include estimates of discharge from the model domain. these estimates should be targets in the calibration, which would make the model more unique.

- As explained previously, the water balance for this hydrologic basin is quite simple with inflow from recharge (explained in UIC application, Section 2.5.2, Table 4, Appendix A-2) and outflow via groundwater underflow at the two gaps in the Gunnison Hills, Walnut Wash and Big Draw. The basin is in steady state, so these two parameters must be equal.
- ADEQ included response to Comment #6.31

  Please see ADEQ response to Comment #6.30.

Simulation of the ISL System

The ISL system involves injection and recovery of acidic solutions within the ore body, using four collection wells for each injection well. However, collection wells will be used with adjacent wells, as shown in Figure 18~~17~~. Injection/recovery rates will vary and may be as high as _100 gpm from individual wells (Attachment A-2~~Appendix I~~, p 25). Overall, the simulated injection is several _thousand gpm for the first ten years and more than 20,000 gpm during the last seven years. most of the water would be recirculated, so this does not represent an ongoing consumptive used.

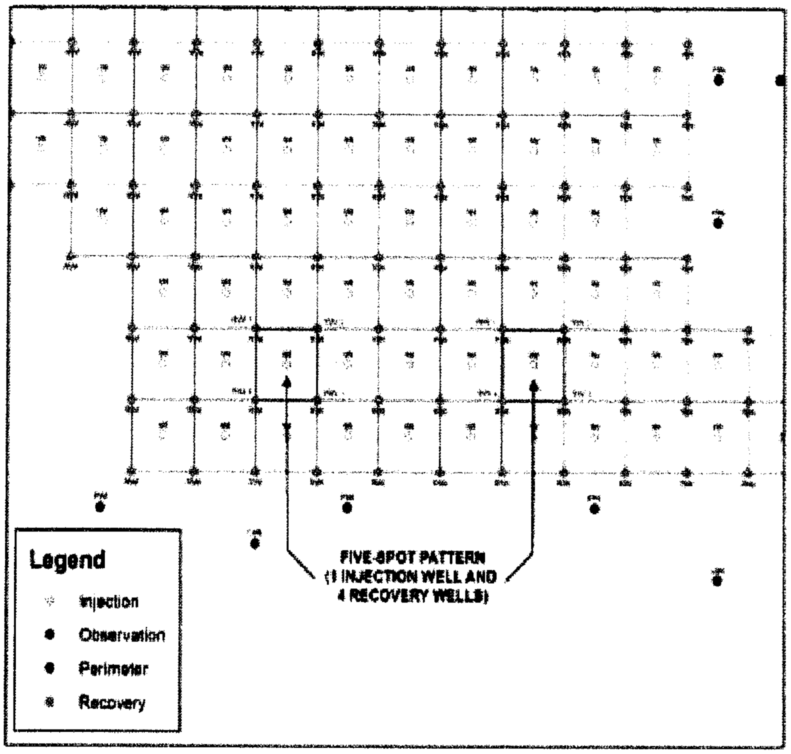


Figure 18~~17~~: Portion of Figure 44, Attachment A-2~~Appendix I~~, showing the five-spot pattern for injection/recovery wells.

The model simulates pumping the hydraulic control wells that surround the well field, but does not simulate the 5-spot injection/collection regime within the well field (Figure 19~~18~~). The hydraulic control well pumping was imposed on the steady state flow simulated in the calibration. Simulations ran for 23 years, simulating each year as a new stress as new blocks of injection/collection wells come on line (Figure 19~~18~~). [redacted]

- Untrue. While the largest drawdowns are centered at the HC wells in Year 10, there is still 19 feet of drawdown in Mine Block 1. This is based on zero net withdrawal within the wellfield (i.e. equal injection and recovery within mining blocks) and all net withdrawal occurring at the HC wells.

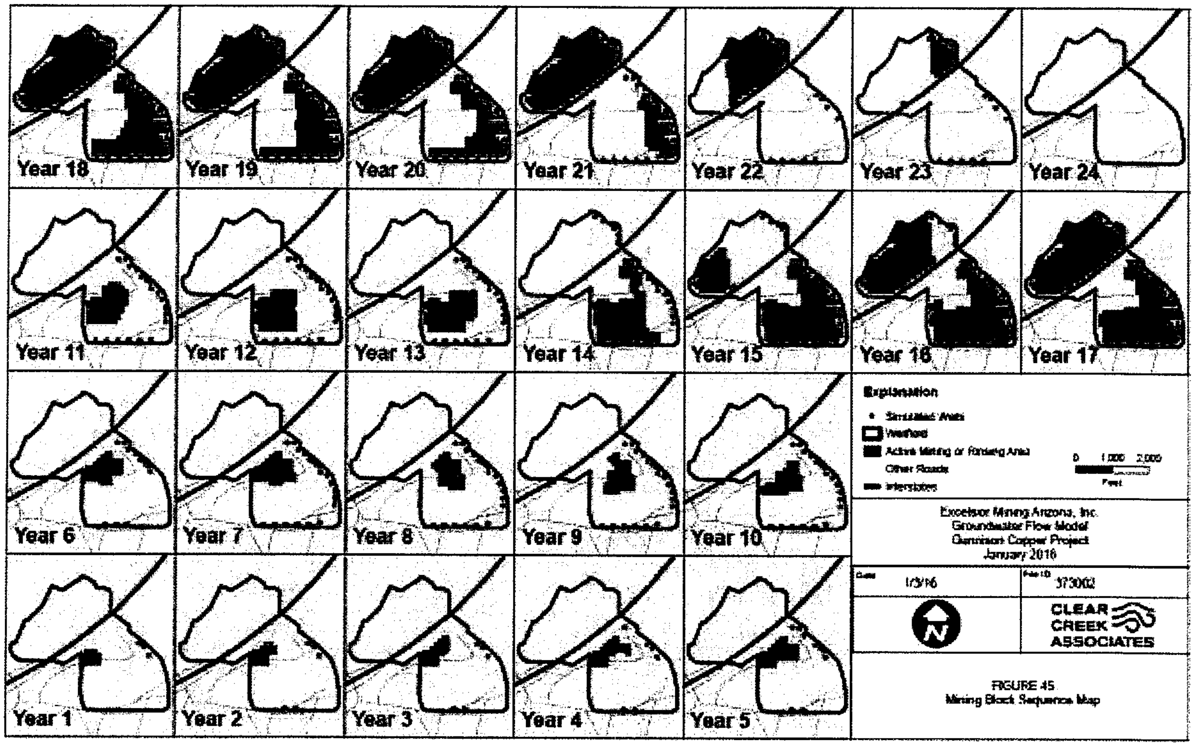


Figure 19~~18~~: Figure 46 from Attachment A-2~~Appendix I~~ showing the progression of mining, in blue, and simulated hydraulic control wells.

The model simulated the transport of contaminants from the mining areas using particle tracking as implemented by the MODPATH model within MODFLOW. The modelers released contaminant particles into the model at the edge of the mining areas (Figure 20~~19~~) at various times based on the progression of mining. Figure 20~~19~~ also shows the simulated hydraulic control wells. Being downgradient from the particle release points, the model simulates all released particles that are captured by the hydraulic control wells (Attachment A-2, Figures 57 – 59).

~~released particles that are captured by the hydraulic control wells (Appendix I, Figures 57 – 59).~~

[redacted]

- The Gunnison groundwater model is based on the detailed geological and structural models, which capture the larger faults and hence the preferential flow paths. This means any preferential flow paths are incorporated in the hydrological model. Particles were used as a general means to assess capture from groundwater flowing away from mine blocks at various times during mining. Average flow paths are appropriate for the containment assessment and incorporate structural heterogeneity.

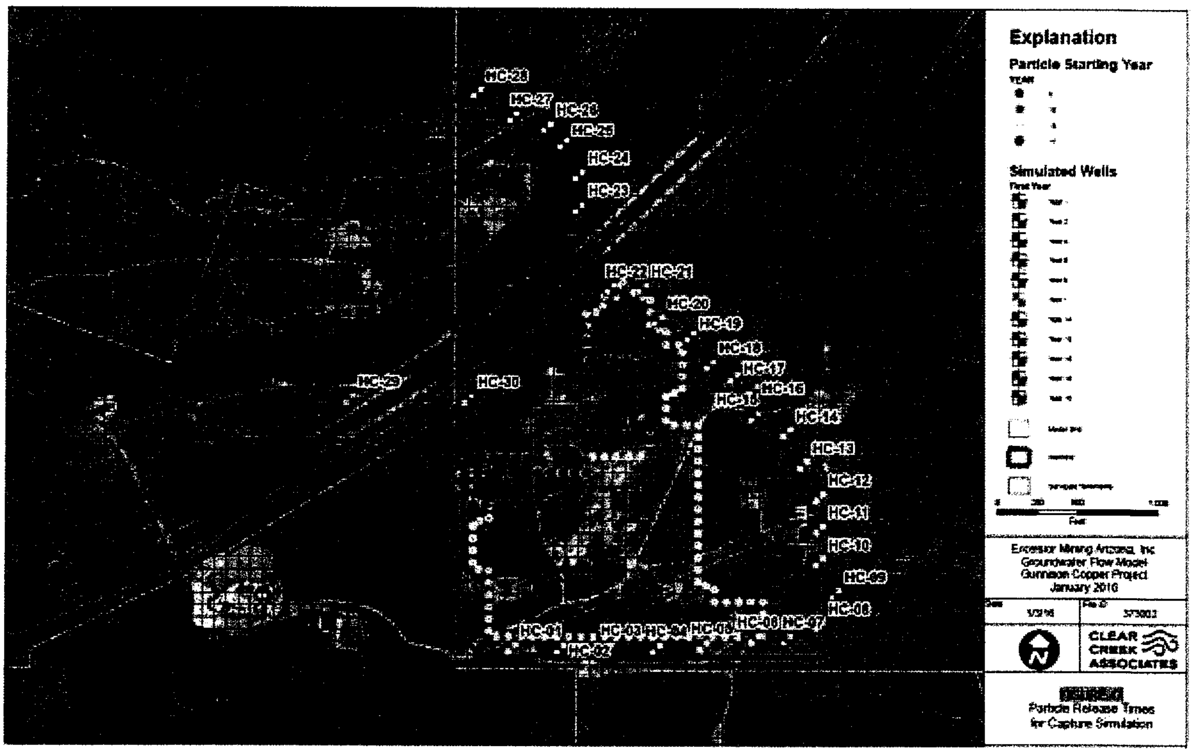


Figure 20~~19~~: Figure 47 from Attachment A-2~~Appendix I~~ showing the location and times that contaminant particles are released for simulation.

The report presents the results in a time series of drawdown maps and particle tracking for contaminants released at various points within the well field. The drawdown maps show the entire well field would eventually have drawdown. This drawdown represents an amount of water that has been removed from storage and would be the difference between injection collection. Drawdown due to the project is the difference between the simulated groundwater level at any given time in the future and the baseline, the steady state water level.

Not all areas within a drawdown cone are areas in which the groundwater flow is toward the middle of the cone. If the baseline groundwater contours dip steeply in one direction, a drawdown may just be a change in slope and the flow may still be away from the cone. Figure

21~~20~~ shows groundwater velocity vectors (arrows showing direction with the length of the arrow proportional to the speed of groundwater flow) and the groundwater contours (not drawdown) for year 21 (not accounting for injection/collection wells). [redacted] the center of the trough. Based on the estimated capture zone line, the yellow line on Figure 21~~20~~ which shows the position of the groundwater divide, the water level is relatively flat throughout the southeast quarter of the wellfield. The mound in the water table represented by the capture zone line is only a few feet higher than the water table in the southeast corner of the project. [redacted]

Figure 21~~20~~: Figure 60 from Attachment A-2~~Appendix I~~ showing the simulated groundwater contours and groundwater velocity vectors for model layer 3, year 21, the end of Stage 3 mining.

The simulation of particle capture and release is not an accurate area, for the following reasons:

- Drawdown throughout the mining area caused by pumping only the hydraulic control wells is unrealistic. The injection wells would be injecting much more fluid into the system than the hydraulic control wells removed. Of course, the collections wells also remove more, but due to the high injection rates and heterogeneities in the well field, there could easily be high pressure injection into flow paths not otherwise captured by collection wells. The combination of injection and recovery wells would create a combination of local mounding and drawdown. Due to the volumes and gradients resulting from the injection/collection wells, the hydraulic control well pumping could be overwhelmed. Without simulating the injection/collection wells, this model does not provide reliable information regarding the effect of the injection/recovery system on local or regional flow paths.

- ADEQ had the following response to APP Comment #6.32

  ADEQ does not agree that discretizing the model to have individual cells for each well is required. The injection and recovery rates within the mine block are to be approximately equal so the water level is maintained. Additional evaluation was conducted in the two Excelsior responses to ADEQ Comments (see ADEQ response to Comment #6.6).

- Contaminants in the model would be released at the edge of the interior well fields (Figures 19~~18~~ and 20~~19~~), but they would not be under pressure as they will be during operations. During operations, the particles would be released at the beginning of a pressurized stream that would cause the particle to move faster than simply being placed at given levels in the aquifer.

- Particles were placed along the outer boundary of mining blocks which is a more conservative location to place them because in reality, outer recovery wells will capture solutions at and some distance outside of mining blocks. Additionally, it is noted that injection and recovery wells are only 70 feet apart which of course favors recovery of mining solutions, the very basis for the success of this mining technique.

- ADEQ had the following response to APP Comment #6.33:

  ADEQ does not agree. Excelsior evaluated how particles would behave when released at the beginning and end of mining certain mining periods. Excelsior in April 2017 Response to ADEQ comments provided additional evaluation of how particles would move if there was an excursion. The following figures shows how far an excursion would go under certain conditions and whether the exclusion would be recovered. The figures are as follows: Figure 8-2 "Closure Strategy Particles and Well Rates Mining Year 1", Figure 8-3 "Closure Strategy Containment after Shutdown Mining Year 1", Figure 8-4 "Closure Strategy Pumping Rates for Wells Mining Year 5 Closure", Figure 8-5 "Closure Strategy Drawdown after Year 8 Mining Year 5 Closure", and Figure 8-6 "Closure Strategy Particles Traces Mining Year 5 Closure" (Please see the attached figures below in ADEQ Response Figures). In addition, the purpose of the IMWs is to evaluate groundwater flow model predictions and evaluate potential fluid channels during operations to prevent large excursions from reaching the POC wells.

- The model simulates pathways that are at a minimum 50-feet wide (model cell sizes) which means the properties are effectively an average over an area that wide. It completely misses the potential narrow pathways that could preferentially allow particles to exit the system.

Simulation of mining should be improved by doing the following:

- The actual injection/recovery wells should be simulated, with injection rates depending on the localized conductivity and pressures that would be acceptable for operations.

- ADEQ had the following response to APP Comment #6.34

  ADEQ does not agree that simulating individual injection/recovery wells in the groundwater flow model is necessary. As discussed in Excelsior's responses to ADEQ's "Comprehensive Request for Additional Information, Gunnison Copper Project – Individual Aquifer Protection Permit – Inventory No. 511633" dated September 1, 2016, Response to ADEQ Comment #8, the groundwater flow model grid size of 75 square feet in the area of the wellfield was based upon a geologic interpretation grid of 50 feet by 100 foot. The 75 square foot grid size is approximately equal to the 5-spot injection/recovery well pattern that was approved for mining. Within the 5-spots, injection and recovery is planning on being approximately equal. Based upon this information and the increased uncertainty of hydrogeologic information for a much smaller grid size, ADEQ does not believe decreasing the grid size adds any predictive value. Nor is requiring Excelsior to individually place one injection/recovery well in each individual model cell necessary.

[redacted]

- ADEQ had the following response to APP Comment #6.35

  ADEQ does not agree with the comment. Please see the response to Comment #6.34 on simulating individual injection/recovery wells.

[redacted]

- ADEQ had the following response to APP Comment #6.36

  ADEQ does not agree with the comment. Please see the response to Comment #6.34 on additional uncertainties created to decrease the groundwater flow model grid size.

[redacted]

the model could simulate a plume that POC wells should be positioned to detect.

Clear Creek should provide figures similar to Figure 21~~20~~ for other time periods and for other model layers. Simply maintaining a drawdown is insufficient; it is necessary to maintain a hydraulic low point wherein no flow from the well field can escape into the regional flow field.

- ADEQ had the following response to APP Comment #6.37:

  ADEQ does not agree that the POC wells should be redesigned based upon contaminant transport modeling or that contaminant transport modeling is required. The constituents that are being monitored are conservative; in that they travel at the same velocity as groundwater, therefore use of particle transport is appropriate.

References

Anderson MA, Woessner WP (1992) Applied Groundwater Modeling, Simulation of Flow and Advective Transport. Academic Press

Clear Creek Associates (CCA) (2016) Aquifer Protection Permit Application, Gunnison Copper Project, Cochise County, Arizona, Prepared for Excelsior Mining Arizona, Inc. Scottsdale AZ